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BULLETIN OF THE IMPERIAL INSTITUTE

A QUARTERLY RECORD OF PROGRESS IN TROPICAL AGRICULTURE AND INDUSTRIES AND THE COMMERCIAL UTILISATION OF THE NATURAL RESOURCES OF THE COLONIES AND INDIA

EDITED BY THE DIRECTOR AND PREPARED BY THE SCIENTIFIC AND TECHNICAL STAFF OF THE IMPERIAL INSTITUTE AND BY OTHER CONTRIBUTORS

HONI SOIT QUI MAL Y PENSE

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ERRATA TO VOL. XVII

p. 136, line 17, *for* Watson *read* Weston.
p. 140, line 25, *for* I.C.S. *read* D.Sc.
p. 356, table, column 2, *for* Tons *read* Cwts.

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THE IMPERIAL INSTITUTE

OF THE

UNITED KINGDOM, THE COLONIES AND INDIA

THE Imperial Institute was erected at South Kensington as the National Memorial of the Jubilee of Queen Victoria, by whom it was opened in May 1893.

The principal object of the Institute is to promote the utilisation of the commercial and industrial resources of the Empire: (i) by arranging comprehensive exhibitions of natural products, especially of the Dominions, Colonies and India; and (ii) by providing for their investigation, and for the collection and dissemination of scientific, technical and commercial information relating to raw materials.

Until the end of 1902 the Imperial Institute was managed by a Governing Body, of which H.R.H. the Prince of Wales (afterwards King Edward VII.) was President, and an Executive Council, including representatives of the Indian Empire and of all the British Colonies and Dependencies. In 1900 the building became the property of H.M. Government, by whom the western portion and galleries were leased to the Governing Body of the Imperial Institute, the greater part of the eastern and central portions being assigned, subject to rights of usage, for occupation by the University of London. In July 1902 an Act of Parliament was passed transferring the management of the Imperial Institute to the Board of Trade, assisted by an Advisory Committee including representatives of the Dominions, Colonies and India, as well as of the Colonial and India Offices, the Board of Agriculture and the Board of Trade.

Under a subsequent arrangement between the Depart-

ments concerned, the Colonial Office became chiefly concerned with the management of the Imperial Institute.

In April 1916 the Imperial Institute (Management) Act was passed transferring the property and management of the Imperial Institute to the Secretary of State for the Colonies. The Act provides for the appointment of an Executive Council consisting of twenty-five members, nominated by the Board of Trade, the Secretary of State for India (two each), the President of the Board of Agriculture and Fisheries, the Government of India, the Governments of the several Dominions (one each), and the Secretary of State for the Colonies (fourteen). A list of the present members of the Council is given on pp. xi and xii and also of the various Committees which have been appointed (pp. xii–xvii).

The staff of the Imperial Institute includes officers with special qualifications in the sciences of chemistry, botany, geology and mineralogy, and in certain branches of technology, in their relation to commerce and to the industrial utilisation of raw materials.

The following are the principal departments of the Institute:

Public Exhibition Galleries.—The collections of raw materials, etc., illustrative of the industrial and commercial resources of the Dominions, Colonies and India, are arranged, together with other exhibits, on a geographical system in the public galleries of the Imperial Institute. The galleries are open free to the public, daily (except on Sundays, Good Friday and Christmas Day), from 10 a.m. to 5 p.m. in summer, and from 10 a.m. to 4 p.m. in winter.

The following British Dominions, Colonies and Dependencies are represented by Collections, which are in charge of Technical Superintendents:

Canada, Newfoundland; Jamaica, Turks and Caicos Islands, British Honduras, British Guiana, Bahamas, Trinidad and Tobago, Barbados, Windward Islands, Leeward Islands, Bermuda; Falkland Islands; New South Wales, Victoria, Queensland, Tasmania, South Australia,

Western Australia, Papua, Northern Territory, New Zealand; Fiji, Western Pacific Islands; Union of South Africa, Rhodesia, Nyasaland, St. Helena; Gambia, Sierra Leone, Gold Coast, Nigeria; East Africa Protectorate, Zanzibar and Pemba; Uganda; Somaliland; Sudan; Malta; Cyprus; Ceylon; Hong Kong; Mauritius; Seychelles; Straits Settlements, the Federated Malay States; and the Indian Empire.

An Egyptian collection is in course of formation.

A reference collection of standard raw materials of commerce is shown in the Upper East Gallery.

Arrangements are made to conduct parties from schools and educational institutions through the Collections and to explain the exhibits. Short lectures on the countries of the Empire and their resources are given periodically in connection with the Collections.

A Central Stand for the distribution of publications and an Enquiry Office have been opened in the main gallery to provide for the supply of general information and the distribution of literature. Handbooks, pamphlets, circulars, etc., containing information relating to the commerce, agriculture, mining and other industries of the Dominions and Colonies, and also in regard to emigration, are available for free distribution or for sale. The publications of the Emigrants' Information Office may also be obtained. Lists of the publications available for distribution or sale are provided, and the principal Colonial and Indian newspapers may be seen on application.

In 1918 the public galleries were visited by 78,090 persons.

Owing to the temporary occupation by Government Departments of a part of the Galleries during the war, some of the facilities referred to above are still restricted, but the Galleries are now being released section by section and the collections reinstated.

Scientific and Technical Research Department.—The technical laboratories and workrooms of this Department were established in order to provide for the investigation of new or little-known raw materials from the Dominions,

Colonies and India, and of known products from new sources, with a view to their utilisation in commerce. Materials investigated by the Department are in promising cases submitted to further technical trials by manufacturers and other experts, and finally are commercially valued.

The work of this Department is chiefly initiated by the Home, Dominion and Colonial Governments and the Government of India. Arrangements have also been made by the Department of Overseas Trade whereby British representatives abroad may transmit to the Institute, for investigation, such raw materials of the countries to which they are appointed as are likely to be of interest to British manufacturers and merchants.

Special analyses and investigations are undertaken for firms or private persons in any part of the Empire on payment of appropriate charges. Application for such investigations should be made, in writing, to the Director.

A Reference Sample Room is maintained in this Department, in which are arranged samples of the principal raw materials which have been investigated and valued commercially during recent years, and as to which full information is available.

The Department works in co-operation with the Agricultural, Mines and other Technical Departments in the Dominions, Colonies and India, whose operations it supplements by undertaking investigations and enquiries of a special scientific or technical character connected with agricultural or mineral development, as well as enquiries relating to the composition and commercial valuation of products (animal, vegetable or mineral) which can be more efficiently conducted at home in consultation with manufacturers and merchants, with a view to the local utilisation of these products or to their export.

A large number of reports on these subjects have been made to the Governments of the Dominions, the Colonies and India, a first instalment of which was printed in a volume of *Technical Reports and Scientific Papers*, published in 1903. A series of Selected Reports is now

being issued in the Miscellaneous Series of Colonial Reports which are presented to Parliament (see p. viii).

Mineral Surveys are conducted in countries of which the mineral resources are little known. All minerals found that are likely to be of commercial importance are forwarded to the Imperial Institute, where they are examined and their composition and commercial value ascertained. Reports on the results of mineral exploration in Ceylon, Northern Nigeria, Southern Nigeria, and Nyasaland have been printed in the Miscellaneous Series of Colonial Reports and presented to Parliament. The work of the Imperial Institute on minerals is carried on with the advice of the Committee on Mineral Resources (see p. xvi).

Technical Information Bureau.—This is a branch of the Scientific and Technical Research Department which has been formed to deal with the large and increasing number of enquiries received by the Imperial Institute from manufacturers, merchants and others, throughout the Empire. The Bureau has devoted special attention to questions relating to the raw materials required for the industries of the Empire. It has supplied technical information to enquirers, and has issued circulars and pamphlets dealing with various problems in connection with the supply and disposal of raw materials of all kinds.

Indian Trade Enquiry.—The Secretary of State for India has requested the Committee for India of the Institute to enquire into and report on the possibilities of extending the industrial and commercial utilisation of Indian raw materials in this country and elsewhere in the Empire. Special Committees have been appointed to deal with the more important groups of Indian materials, to consider the results of investigations and enquiries already conducted at the Imperial Institute, and to obtain the views of leading merchants, manufacturers, and other users of the raw materials of India. A number of reports have already been furnished to the India Office, and

arrangements are now being made for their publication. A list of the members of these Special Committees is given on pp. xiv and xv.

Tropical African Services Course.—Courses of instruction in certain specified subjects are given at the Imperial Institute to candidates selected by the Colonial Office for administrative appointments in East and West Africa. Instruction in these Courses in the subject of Tropical Economic Products is given by a member of the Staff of the Imperial Institute. The Courses have been temporarily discontinued since the war.

Library, Reading-Rooms and Map-Room.—The library and reading-rooms of the Imperial Institute contain a large collection of works of reference, and are regularly supplied with the more important official publications, and with many of the principal newspapers and periodicals of the United Kingdom, the Dominions, the Colonies, India and Foreign Countries. Special attention is given to publications relating to tropical agriculture and forestry, mineral resources, and the production and utilisation of raw materials.

The map-room, which adjoins the reading-rooms, is provided with a large collection of recent maps of the Dominions, the Colonies and India, which can be seen on application.

Colonial Conference Rooms.—These rooms, specially decorated and furnished, are reserved on the principal floor for use by representatives of the Dominions and Colonies and for meetings and receptions.

The Cowasjee Jehangier Hall.—The Bhownaggree corridor and rooms in connection with the Cowasjee Jehangier Hall are in the occupation of the Indian Section of the Imperial Institute, whilst the Hall is available for lectures, meetings, etc.

Publications

Bulletin of the Imperial Institute.—The BULLETIN is published quarterly by Mr. John Murray, 50A, Albemarle Street, London, price *2s. 6d.* (annual subscription 11*s.*, including postage), and may be purchased through any bookseller. It contains records of the principal investigations carried out at the Imperial Institute, and special articles chiefly relating to the industrial utilisation of raw materials and progress in tropical agriculture.

Handbooks to the Commercial Resources of the Tropics.—The Secretary of State for the Colonies has authorised the preparation of a series of handbooks dealing with the Commercial Resources of the Tropics, with special reference to West Africa. The handbooks are edited by the Director of the Imperial Institute and published by Mr. John Murray. The first four volumes are: *The Agricultural and Forest Products of British West Africa*, by Gerald C. Dudgeon, Consulting Agriculturist, Ministry of Agriculture, Egypt, and lately Inspector of Agriculture for British West Africa, price 6*s.* net; *Cocoa: Its Cultivation and Preparation*, by W. H. Johnson, F.L.S., Director of Agriculture in Southern Nigeria, price 6*s.* net; *Rubber: Its Sources, Cultivation and Preparation*, by Harold Brown, Technical Superintendent, Scientific and Technical Department, Imperial Institute, price 6*s.* net.; and *Cotton and other Vegetable Fibres: their Production and Utilisation*, by Ernest Goulding, D.Sc., F.I.C., Scientific and Technical Department, Imperial Institute, price 6*s.* net.

Monographs on Industrial Resources.—The Imperial Institute has devoted special attention to the question of securing the utilisation in the United Kingdom of the large quantities of materials produced within the Empire which before the war were exported chiefly to foreign countries. It is intended to deal with this subject in a series of Monographs. In order to call attention to the subject of oil seeds, a monograph, entitled *Oil Seeds and Feeding Cakes*, has been issued. This book, which is published

by Mr. John Murray, price 2*s.* 6*d.* net, deals with the production and utilisation of copra, palm kernels, ground nuts, sesame seed and mowra seed, and the oils and feeding cakes obtained from them.

Monographs on Mineral Resources.—The Mineral Resources Committee of the Imperial Institute have arranged for the publication of a series of monographs on mineral resources with special reference to those of the British Empire.

The first of these monographs, dealing with Zinc Ores, has been published, and may be obtained from the Imperial Institute, price 2*s.* post free. It gives a short statistical account of the world's production of zinc and zinc ores, and describes the minerals of zinc which serve as ores of the metal. This section is followed by an account of the principal zinc deposits of the Empire, special attention being given to Australia, the United Kingdom, Canada and India, which are the principal British sources of supply. Reference is also made to the more important deposits in foreign countries. The last section deals briefly with the uses of zinc for galvanising, the manufacture of alloys, etc.

Monographs on Manganese Ores, Tin Ores and Tungsten Ores are in the press, and other monographs are in preparation.

Map and Diagrams of the Chief Metal Resources of the Empire.—This publication, prepared at the Imperial Institute with the advice of the Imperial Institute Committee on Mineral Resources, is now issued. The chief British countries of occurrence and production of the principal minerals are shown on the map. The diagrams give the outputs of these countries for 1915 in relation to the production of other countries of the world. The metals dealt with are: gold, silver, platinum, copper, tin, lead, zinc, antimony, aluminium, bismuth, iron, manganese, chromium, nickel, tungsten, molybdenum, vanadium, and mercury.

The map and diagrams are mounted on linen and folded. The publication is obtainable from the Imperial Institute, price 5*s.* 6*d.* (post free).

Selected Reports from the Scientific and Technical Department.—These reports, which are issued in the Miscellaneous Series of Colonial Reports, contain a summary of the results of technical and commercial investigation of raw materials conducted in the Scientific and Technical Research Department of the Imperial Institute since 1903. Five of these Selected Reports have been published: Part I. "Fibres"; Part II. "Gums and Resins"; Part III. "Foodstuffs"; Part IV. "Rubber and Gutta Percha"; Part V. "Oilseeds, Oils, Fats and Waxes."

Organisations with Headquarters at the Institute

International Association for Tropical Agriculture, British Section.—The object of this Association, the Central Bureau of which is in Paris, is to promote the scientific and practical study of all questions connected with tropical agriculture, including the development and utilisation of natural resources, and to arrange for International Congresses. The British Section has its headquarters at the Imperial Institute. Members of the British Section receive the Bulletin of the Imperial Institute and are permitted to use the library and reading-rooms of the Imperial Institute.

British Women's Emigration Association.—The British Women's Emigration Association has offices on the mezzanine floor, which are open daily from 10 a.m. to 4 p.m. Advice and information respecting emigration and prospects for women in the Dominions may be obtained there free of charge. This Association works in co-operation with the Emigrants' Information Office in Westminster.

Overseas Nursing Association.—An office on the mezzanine floor has been allotted to this Association, the principal object of which is the selection of trained hospital and private nurses for service in the Crown Colonies and Dependencies.

Tropical Diseases Bureau.—Temporary office accommodation on the mezzanine floor has been provided for this Bureau, the main purpose of which is to collect information regarding tropical diseases and to distribute it as widely as possible among those who are engaged in combating such diseases.

Universities Bureau of the British Empire.—An office on the mezzanine floor has been allotted to this Bureau, the object of which is the collection and dissemination of information relating to the Universities of the British Empire.

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[In addition to the Committees in which their names are included, the Chairman of the Executive Council and the Director of the Imperial Institute are *ex-officio* Members of all Committees.]

[1] *Nominated by the Silk Association of Great Britain and Ireland.*

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Since the outbreak of war, the following members of the Staff of the Imperial Institute have joined H.M. Forces:

Assistant Secretary to the Director: The Hon. T. L. McClintock Bunbury, M.A. (Cantab.).

Scientific and Technical Staff: F. Boulton; G. T. Bray, A.I.C.; H. J. Broughton; W. G. Creasy; W. S. Davey; H. Johnson,[1] B.Sc. (Lond.); T. McLachlan, D.C.M., A.I.C.; G. L. Matthews, M.C., B.Sc. (Lond.), A.I.C.; V. W. Newman[1]; F. W. Rolfe; D. J. Taylor,[1] B.Sc. (Lond.); J. D. F. West, A.I.C.; B. W. Whitfeild; W. O. R. Wynn, A.I.C.

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[1] *Killed.* [2] *Missing, assumed killed.*

REPORTS OF RECENT INVESTIGATIONS AT THE IMPERIAL INSTITUTE

The following summaries have been prepared from a selection of the Reports made by the Director of the Imperial Institute to the Dominion, Colonial and Indian Governments.

THE QUALITY OF INDIAN OPIUM CONSIDERED IN RELATION TO ITS USE IN MEDICINE

A SYSTEMATIC investigation of Indian opium has been carried out at the Imperial Institute for some years past with the objects of establishing the average composition of the Indian drug and determining its suitability for use in Europe for medicinal and manufacturing purposes.

It was formerly believed that Indian opium usually contained a much lower percentage of morphine than Turkey or Persian opium, but the results of the examination at the Imperial Institute of nearly 200 samples from different districts in India conclusively showed that this view was erroneous and that supplies of Indian opium averaging 10 per cent. of morphine (the British Pharmacopœia standard) or more can be readily obtained from certain areas.

The establishment of this fact was of the utmost importance in connection with the future of the trade in Indian opium, and so long ago as 1896 the Imperial Institute suggested to the Government of India that the production of medicinal opium for export to Europe should be undertaken. No action was, however, taken in this direction until 1907, when the question was again considered at the suggestion of the Imperial Institute in connection with the restrictions which were then placed on the future export of Indian opium to China. Finally, after the outbreak of the war the Government of India permitted the export of a certain quantity of opium to the United Kingdom for use by manufacturers of morphine, and it is hoped that the trade thus begun will be developed and firmly established.

The proof that Indian opium is of much better quality than was previously supposed is mainly due to the investigations conducted at the Imperial Institute, and it is of interest to find that the question of the production of high-grade opium in India is at last receiving from the Government the attention which it deserves. There is no reason why India should not supply in future a large proportion of the opium used in the United Kingdom for medicinal purposes or for the manufacture of morphine and codeine.

A full account of the earlier investigations of Indian opium at the Imperial Institute has already been published in this BULLETIN (1915, **13**, 507), and in the present article it is proposed to give the results of further work.

In July 1915 a set of 80 samples of opium from the United Provinces was received with the request that they might be examined at the Imperial Institute in order to check the results of analyses of identical samples which had been carried out at the Ghazipur factory, and of which a copy was furnished. Independent analyses of 22 of the samples made in London by manufacturers were also supplied to the Imperial Institute by the India Office.

At the suggestion of the Imperial Institute, representative samples of the different kinds of opium available for export from India were forwarded by the Factory Superintendent at Ghazipur, in December 1915.

These samples are dealt with in the present article.

SERIES NO. 1

The object in view in collecting this series of samples was to determine: (1) the localities where opium suitable for medicinal purposes in Europe could be produced, and (2) the best varieties of poppy for cultivation.

The 80 samples represented the opium produced in the different divisions of the United Provinces from known varieties of poppy. Notes stating the nature of the soil on which the plants were grown, the manure used and other details were also furnished.

In view of the fact that 75 of the 80 samples had been already analysed in India, it was thought that a sufficient check on the results would be obtained if a certain number were selected for re-examination at the Imperial Institute.

It was therefore decided to examine all samples, numbering 24, which the analyses made in India or by the manufacturers showed to contain 9 per cent. or more of morphine.

The samples as received were contained in hermetically sealed tins and weighed about 1 lb. In every case the opium was in a moist pasty condition, and the majority of the samples had developed mould to a varying degree. The portions affected with mould were separated as far as possible before taking a sample for analysis.

The results obtained in the examination of the 24 selected samples are summarised in the following table:

No.	Variety of poppy.	Moisture.	In dry opium.			
			Morphine.[1]	Codeine.[2]	Narcotine.	Aqueous extract.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
52	Posti	18·72	14·25	2·91	7·61	60·32
83	Katila	30·36	13·62	1·86	5·74	62·34
54	Baunia (dwarf)	19·00	13·44	3·93	5·27	68·37
95	Karria or Damia	17·70	13·27	3·35	7·01	69·90
79	Katila (or Chansura Changhaha)	18·87	12·65	2·91	7·54	61·70
5	Bharbharwa or Katila	20·12	12·54	3·24	6·19	63·60
92	Katila	18·17	12·34	3·24	7·12	65·54
16	Desi	17·43	12·07	3·72	4·86	67·38
98	Katila and Telia	13·24	11·91	3·57	6·40	65·69
109	Safed Posta	24·03	11·83	2·81	5·96	69·45
6	Maghaiya	19·18	11·80	3·46	4·90	64·73
40	Hariala	20·29	11·48	3·13	5·34	62·96
49	Safeda	17·65	11·45	3·67	6·64	67·19
39	Baunia (dwarf)	24·06	11·40	2·5	4·3	55·62
113	Safeda	25·25	11·26	3·39	6·69	69·13
19	Safaid danti	17·14	11·16	3·54	5·78	64·0
31	Kali danti	17·53	11·16	4·02	6·44	64·04
66	Kotila	27·43	10·98	2·81	7·13	64·33
65	Kotila	24·88	10·95	3·61	6·16	61·21
56	Katila and Bounria	20·98	10·33	3·41	6·07	61·88
41	Hariala	22·33	10·31	3·37	3·95	63·53
14	Telia	19·43	10·31	3·72	5·09	63·06
68	Harera	19·09	9·85	3·69	7·34	66·39
55	Baunia (dwarf)	20·80	9·57	3·98	4·52	67·89
—	Average	—	11·66	3·33	6·00	64·55

[1] *Determined by the method given in the "British Pharmacoœia"* (1914).
[2] *Determined by the method described in "The Analyst"* (1911, 36, 489).

In the following table a comparison is given of the percentages of morphine found in these samples: (*a*) at the Imperial Institute, (*b*) in India, and (*c*) by manufacturers in London. In the latter case analyses of only eight of the samples are available.

No. of sample.	Morphine.		
	Imperial Institute figures.	Indian figures.	Manufacturers' figures.
	Per cent.	*Per cent.*	*Per cent.*
52	14·25	11·5	—
83	13·62	11·65	—
54	13·44	10·7	10·2
95	13·27	9·15	—
79	12·65	9·2	10·3
5	12·54	8·9	9·6
92	12·34	9·6	9·5
16	12·07	9·83	7·0
98	11·91	9·6	—
109	11·83	10·65	—
6	11·80	9·5	—
40	11·48	9·83	—
49	11·45	9·78	—
39	11·40	10·4	—
113	11·26	9·5	—
19	11·16	9·36	8·3
31	11·16	9·02	—
66	10·98	9·8	—
65	10·95	9·35	—
56	10·33	9·0	5·8
41	10·31	9·69	—
14	10·31	9·12	—
68	9·85	9·05	7·2
55	9·57	9·15	—
Average	11·66	9·72	—

A comparison of the amounts of morphine found in these three sets of analyses shows that the Imperial Institute results are invariably higher than those obtained in India, the increases ranging from 0·42 to 4·12 per cent., with an average of 1·94 per cent. As already stated, the method used at the Imperial Institute for determining the morphine is that of the *British Pharmacopœia* (1914). No information was furnished as to the process used in India for these particular analyses, but the differences appear to be far too large in many cases to be attributed merely to different methods of analysis. The explanation of the discrepant results may be that the samples examined in India and at the Imperial Institute were not identical.

The analyses of the eight samples made separately in London by manufacturers do not agree with those made in India or at the Imperial Institute. In five cases they are lower than the Indian figures, in two cases higher and in one practically identical, whilst they are much

below the Imperial Institute figures in all cases. These results again suggest that there was some variation in the different sets of samples.

From the results obtained at the Imperial Institute which are tabulated on page 4, it will be seen that in the twenty-four samples selected for analysis the percentage of morphine varies from 9·57 to 14·25, the average being 11·66 per cent. The *British Pharmacopœia* requires that opium used in medicine for preparations other than the tincture and extract shall contain, when dry, not less than 9·5 per cent. and not more than 10·5 per cent. of anhydrous morphine; the tincture and extract of opium which are standardised to contain a definite percentage of morphine, are permitted to be made from any suitable variety of opium containing not less than 7·5 per cent. of morphine. It is evident, therefore, that these twenty-four samples, forming nearly one-third of the whole consignment, conform to the higher standard of the *Pharmacopœia*, and would bear considerable dilution with lower-grade opium so as to reduce the average percentage of morphine to 10 per cent. The opium would then be perfectly suitable for medicinal use in the United Kingdom.

The average amount of codeine present in these twenty-four samples of opium, viz. 3·33 per cent., is somewhat higher than usual and the percentage of narcotine lower than is frequently found in Indian opium.

Taken as a whole, therefore, the composition of these twenty-four opiums is very satisfactory, and the results fully confirm those recorded in the previous report (*loc. cit.*, p. 523).

It may be mentioned that the percentage of morphine in five other samples of the opium was determined at the Imperial Institute in connection with the consideration of the quality of the opium yielded by different varieties of poppy, and the results may be given here:

	Percentage of morphine.	
	Imperial Institute figures.	Indian figures.
No. 36	10·11	8·7
,, 53	9·90	8·3
,, 82	11·59	7·75
,, 110	10·17	8·45
,, 111	9·34	8·2

It will be seen from the Imperial Institute figures that only one of these five samples contains less than 9·5 per cent. of morphine, and that in this sample the deficiency is only 0·16 per cent.

The percentages of morphine found in India are invariably too low, but their consideration will give an idea of the quality of the consignment as a whole. The results of the Indian analyses of seventy-five out of the total of eighty samples may be summarised thus :

2	samples	contained	between	11	and	12	per cent.	of morphine.
3	,,	,,	,,	10	,,	11	,,	,, ,,
18	,,	,,	,,	9	,,	10	,,	,, ,,
26	,,	,,	,,	8	,,	9	,,	,, ,,
16	,,	,,	,,	7	,,	8	,,	,, ,,
9	,,	,,	,,	6	,,	7	,,	,, ,,

1 sample contained less than 6 per cent. of morphine.

According to these Indian figures, two-thirds of the samples contain 8 per cent. or more of morphine, but taking into account the lowness of the results, it seems probable that the majority of the samples would reach the standard of 9·5 per cent. when examined by the method prescribed by the *British Pharmacopœia.*

As already stated, the object in collecting these samples was to determine : (1) the localities in the United Provinces where opium suitable for medicinal use in Europe could be produced, and (2) the best varieties of poppy for cultivation. The following observations may be offered on these points in the light of the results obtained in the examination of the samples.

(1) *Localities suitable for the production of Good Quality Opium*

Twenty-eight out of the twenty-nine samples of these opiums examined at the Imperial Institute contained more than 9·5 per cent. of morphine, and twenty of them would require dilution with a lower-grade opium in order to reduce the amount of morphine to 10 per cent., which is the standard of the *British Pharmacopœia* for medicinal opium.

The localities from which these 29 opiums were obtained are shown in the following table :

No.	Division.	Sub-division.	Morphine. Per cent.
52	Hardoi	Unao	14·25
83	Fyzabad	Akbarpur	13·62
54	Lucknow	Lucknow	13·44
95	Gonda	Utraula ?	13·27
79	Fyzabad	Fyzabad	12·65
5	Ghazipur	Benares	12·54
92	Gonda	Gonda	12·34
16	Basti	Basti	12·07
98	Gonda	Bahraich ?	11·91
109	Rae Bareli	Rae Bareli	11·83
6	Ghazipur	Benares	11·80
82	Fyzabad	Akbarpur	11·59
40	Budaon	Bisauli	11·48
49	Hardoi	Hardoi	11·45
39	Budaon	Dataganj	11·40
113	Rae Bareli	Maharajganj	11·26
19	Etawah	Etawah	11·16
31	Bareilly	Shahjahanpur	11·16
66	Lucknow	Sidhauli	10·98
65	Lucknow	Sidhauli	10·95
56	Lucknow	Sitapur	10·33
41	Budaon	Bisauli	10·31
14	Azamgarh	Ballia	10·31
110	Rae Bareli	Dalman	10·17
36	Budaon	Budaon	10·11
53	Hardoi	Unao	9·90
68	Bara Banki	Bara Banki	9·85
55	Lucknow	Lucknow	9·57
111	Rae Bareli	Dalman	9·34

The 80 samples of opium were collected from 15 divisions of the United Provinces, and the above 29 samples include specimens from 12 of these divisions, distributed as follows: Lucknow, 5 samples; Budaon and Rae Bareli, 4 each; Gonda, Hardoi and Fyzabad, 3 each; Ghazipur, 2; Azamgarh, Basti, Etawah, Bareilly and Bara Banki, 1 each. It is evident that opium of good quality, suitable for medicinal use in the United Kingdom, can be produced in any of these divisions, and probably in the other three divisions as well.

(2) *Influence of the Variety of Poppy on the Quality of the Opium*

In considering the question of the varieties of poppy which yield the best opium, it is not easy to arrive at definite conclusions from the available data, especially as the conclusions in some cases can only be based on the results given by one or two samples of opium, whereas the varieties more numerously represented sometimes show great variations in the quality of the opium which they yield.

The three varieties of poppy which furnished the

opiums containing the highest percentages of morphine were "Posti," "Katila" and "Baunia" (see table on page 3). These three varieties were each represented by several samples of opium, and the results for both the "Katila" and "Baunia" varieties are very satisfactory as a whole. The samples representing the "Posti" variety showed great variation in the amount of morphine present, and in general were less satisfactory than those of the other two varieties, although one sample was exceptional in containing 14·25 per cent. of morphine, the highest percentage found in the samples examined at the Imperial Institute.

The results obtained for the opiums from these three varieties of poppy both at the Imperial Institute and in India are shown in the following table:

No. of sample.	Division.	Sub-division.	Percentage of morphine. Imperial Institute results.	Percentage of morphine. Indian results.
Variety "*Katila*":				
83	Fyzabad . .	Akbarpur . .	13·62	11·65
92	Gonda . .	Gonda . . .	12·34	9·60
79	Fyzabad . .	Fyzabad . .	12·65	9·2
5	Ghazipur . .	Benares . .	12·54	8·9
93	Gonda . .	Gonda . . .	—	8·35
50	Hardoi . .	Sandila . .	—	7·84
82	Fyzabad . .	Akbarpur . .	11·59	7·75
Average figures for "Katila" variety . .			12·55 (5 samples)	9·04 (7 samples)
Variety "*Baunia*" (dwarf):				
54	Lucknow . .	Lucknow . .	13·44	10·7
39	Budaon . .	Dataganj . .	11·40	10·4
36	Budaon . .	Budaon . .	10·11	8·7
55	Lucknow . .	Lucknow . .	9·57	9·15
37	Budaon . .	Budaon . .	—	8·6
38	Budaon . .	Dataganj . .	—	8·26
Average figures for "Baunia" variety. . .			11·13 (4 samples)	9·3 (6 samples)
Variety "*Posti*":				
52	Hardoi . .	Unao . . .	14·25	11·25
110	Rae Bareli . .	Dalman . .	10·17	8·45
53	Hardoi . .	Unao . . .	9·90	8·3
111	Rae Bareli . .	Dalman . .	9·34	8·2
102	Partabgarh . .	Partabgarh . .	—	8·05
106	Partabgarh . .	Fatehpur . .	—	7·85
103	Partabgarh . .	Partabgarh . .	—	6·9
Average figures for "Posti" variety . . .			10·91 (4 samples)	8·43 (7 samples)

The following varieties of poppy were represented by only one or two samples, but they appear well worth consideration as it is evident that opium rich in morphine can be furnished by them :

Variety of poppy.	No of sample.	Percentage of morphine. Imperial Institute figures.	Percentage of morphine. Indian figures.
Kotila (Katila ?)	66	10·98 } Av. = 10·96	9·8 } Av. = 9·58
" "	65	10·95	9·35
Safeda	49	11·45 } Av. = 11·36	9·78 } Av. = 9·64
"	113	11·26	9·50
Hariala	40	11·48 } Av. = 10·9	9·83 } Av. = 9·76
"	41	10·31	9·69
Karria or Damia	95	13·27	9·15 } Av. = 8·75
" "	94	—	8·35
Desi	16	12·07	9·83 } Av. = 8·82
"	15	—	7·80
Safed Posta	109	11·83	10·65 } Av. = 9·7
" "	108	—	8·75
Safaid danti	19	11·16	9·36 } Av. = 9·02
" "	20	—	8·69
Telia	14	10·31	9·12 } Av. = 7·66
"	10	—	6·2
Kali danti	31	11·16	9·02 } Av. = 8·5
" "	25	—	8·83
" "	1	—	7·89

Attention has already been drawn to the variations which occur in the percentage of morphine present in samples of opium derived from the same variety of poppy, and, with a view to finding some explanation of these differences, a comparison may be made of the samples yielded by the three varieties " Katila," " Baunia " and " Posti " (see table on page 8).

Opium from the " Katila " Poppy.—The five samples of " Katila " opium examined at the Imperial Institute were all of very good quality, the percentages of morphine ranging from 11·59 to 13·62 per cent., with an average of 12·55 per cent. The Indian results for seven samples give an average of 9·04 per cent. of morphine.

A comparison of the Imperial Institute figures shows that Nos. 82 and 83 contain 11·59 and 13·62 per cent. of

morphine respectively, the difference being about 2 per cent. The two samples came from the same sub-division (Akbarpur), and both crops received the same manurial treatment, the only recorded difference being in the nature of the soil, which was loam in the case of the richer sample No. 83 and clay in No. 82.

The other three samples of this variety examined at the Imperial Institute agree closely in the amounts of morphine present, and in these cases there was little variation in the nature of the soils, which were described as loam or sandy loam.

The results suggest that this variety of poppy, when grown on a clay soil, may yield opium containing a lower percentage of morphine than when grown on a loam.

Opium from the "Baunia" Poppy.—There were six samples of opium representative of this variety of poppy, and four of these were examined at the Imperial Institute. The Imperial Institute analyses gave from 9·57 to 13·44 per cent. of morphine, with an average of 11·13 per cent., whilst the Indian results for the six samples ranged from 8·26 to 10·7 per cent. with an average of 9·3 per cent.

Nos. 54 and 55, both from the Lucknow sub-division and treated with the same manures, differed in quality by nearly 4 per cent. of morphine according to the Imperial Institute figures and by 1·5 per cent. taking the Indian results. The better sample (No. 54) was produced on a clay soil, and the other on a sandy loam. In this case, therefore, the possible connection between the kind of soil and the quality of the opium is the reverse of that suggested by the results obtained with the "Katila" opiums. The only other recorded difference between these two "Baunia" samples is in the kind of crop grown previously on the land; sugar-cane preceded the crop which furnished the better opium, and cotton was grown previously in the case of the other sample.

A comparison of samples Nos. 38 and 39, both from Dataganj sub-division, shows them to differ in quality by about 2 per cent. of morphine according to the Indian figures. In this case the better sample came from a sandy loam, and the other from a clay soil, thus reversing

the relationship with the nature of the soil shown by the two "Baunia" samples from Lucknow. The two remaining samples of this variety (Nos. 36 and 37) were similar in quality although grown respectively on a clayey loam and a light sandy loam.

Opium from the "Posti" Poppy.—A comparison of the samples of opium furnished by the "Posti" variety of poppy shows the same variations, which cannot be accounted for by the recorded conditions. The four samples examined at the Imperial Institute differ by nearly 5 per cent. of morphine, the figures ranging from 9·34 to 14·25 per cent.

Samples Nos. 52 and 53, both from Unao sub-division, were obtained from similar soils using the same manures, yet the opiums differed by 4·3 per cent. of morphine. It is recorded that, in the case of the better sample, the previous crop was poppy and with the inferior sample "Arhar" (*Cajanus indicus*, the pigeon pea). There is again a distinct difference (according to the Indian figures) between samples Nos. 102 and 103, which cannot be attributed to differences in district, soil or manure. In the case of Nos. 110 and 111 the variation in quality is not very marked, although the soils differed.

The comparison of the samples of opium from the same variety of poppy in conjunction with the recorded information as to the conditions under which the plants were grown does not permit any satisfactory conclusion to be drawn as to the cause of the variation in the amount of morphine present, and it can only be concluded that conditions other than those recorded have an important influence on the quality.

The results, however, clearly indicate that opium of exceptionally good quality can be obtained in particular districts from certain varieties of poppy. In the absence, therefore, of more definite information the only suggestion which can be made is that where a particular variety has been found to produce a rich opium under certain conditions, the cultivation of this variety should be encouraged in districts where the conditions are favourable. The varieties noted on pages 8 and 9 are well worth consideration for cultivation purposes. The yield

of opium from the different varieties is also a point of importance, which will require to be taken into account in this connection.

Reference may here be made to the results of the experimental cultivation of seven varieties of poppy occurring in the United Provinces which are recorded in the *Annual Report for* 1915–16 *on the Kumaun Government Gardens.* The Superintendent of the Gardens, in drawing his conclusions from the experiments, stated: "It remains to be seen whether or not such varieties as 'Katila,' 'Sufaidah,' and 'Hariala,' with their low morphine contents, are worthy of encouragement." This conclusion as regards the varieties "Katila" and "Hariala" is not in agreement with the results recorded in the present report, which clearly indicate the value of the "Katila" variety for the production of opium rich in morphine.

The results of the investigation which is being conducted by the Economic Botanist in the United Provinces, in conjunction with the Agricultural Chemist to the Government of Bengal, on the different varieties of poppy and the quality of opium which they furnish, should be of the greatest value in selecting the best varieties for extended cultivation.

Series No. 2.

As already mentioned, these samples represent the different kinds of opium available for export from India.

Fifteen samples were forwarded, seven being described as "Provision Opium Reserve (Benares crude opium)," five as "Benares crude opium" and the remaining three as "Malwa manufactured opium." They were contained in soldered tins and weighed about 1 lb. each; with the exception of the three Malwa specimens, they were all in the form of a moist paste, and mostly mouldy on the surface. Analyses of the fifteen samples were made on the same lines as with the previous samples examined at the Imperial Institute (see p. 2), and the results are given in the following table:

	Moisture.	Calculated on the dry opium.			
		Morphine.	Codeine.	Narcotine.	Aqueous extract.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
(1) Vat S Provision opium reserve (Benares crude opium)	27·21	10·3	3·87	6·08	64·6
Vat W ditto	27·11	10·24	4·17	5·51	62·0
,, A ,,	27·51	11·26	3·91	5·70	68·03
,, D ,,	28·46	10·41	3·69	5·37	65·06
,, F ,,	28·45	10·02	3·76	5·47	66·06
,, U ,,	30·34	10·39	3·97	5·43	65·08
,, V ,,	31·3	10·50	3·85	5·06	64·66
Average figures for above 7 samples	—	10·45	3·89	5·52	65·07
(2) Vat C Benares crude opium	23·37	10·81	3·78	6·49	65·89
,, M ditto	24·53	11·01	4·17	6·05	67·08
,, G ,,	26·52	10·84	4·02	5·84	64·20
,, N ,,	38·80	10·05	3·80	2·32	62·49
,, O ,,	32·54	9·91	3·71	5·22	66·65
Average figures for above 5 samples	—	10·52	3·89	5·18	65·26
(3) Vat 2 Malwa manufactured opium	8·06	8·49	3·31	7·27	65·40
,, 4 ditto	7·52	8·38	3·09	6·94	60·70
,, 7 ,,	7·30	9·45	3·24	7·62	64·51
Average figures for above 3 samples	—	8·77	3·21	7·28	63·54

These samples, excepting the last three (Vats 2, 4 and 7), consisted of crude Benares opium collected and received at Ghazipur in the spring of 1915. The first seven samples, described as "Provision opium reserve," represent the crude opium intended for the manufacture of "Provision" opium cakes. The samples of Malwa manufactured opium (Vats 2, 4 and 7) were stated to have been purchased by the Government in 1915.

A consideration of the analytical figures given in the preceding table indicates that the twelve samples of Benares crude opium are of good quality and fairly uniform in composition. They all contain more than 9·5 per cent. of morphine, the figures varying from 9·91 to 11·26 per cent. with an average of 10·48 per cent. These samples are therefore very satisfactory as regards the amount of morphine present, and would be quite suitable for manufacturing purposes or for medicinal

use in the United Kingdom. For the latter purpose, the low percentages of narcotine would be an advantage, as objection has sometimes been raised to the medicinal use of Indian opium on account of the large amount of narcotine frequently present in it.

The results also show that these Benares samples contain a high percentage of codeine, viz. 3·9 per cent., a fact which should be taken into account when considering the use of the opium for manufacturing purposes. Turkish opium furnishes less than 1 per cent. of codeine on the average, and Persian opium about 2·5 per cent.

The three samples of Malwa manufactured opium are inferior to the Benares samples, both on account of the smaller proportion of morphine and also the larger amount of narcotine. Only one of the samples (Vat 7) reaches the standard of 9·5 per cent. of morphine.

THE USE OF INDIAN KAPOK IN LIFE-SAVING APPLIANCES

KAPOK, on account of its great buoyancy and freedom from water-logging, has been employed to a large extent in recent years in the manufacture in this country of life-buoys, life-belts, waistcoats, seat covers, and other appliances used for saving life at sea. The Board of Trade regulations stipulate, however, that only Java kapok may be employed for such purposes. Java kapok consists of the seed-hairs of *Eriodendron anfractuosum*, and, although this tree occurs in India, most of the Indian kapok is obtained from the so-called cotton-tree, *Bombax malabaricum*, and therefore does not in this respect meet the requirements of the Board of Trade. In 1916 the Imperial Institute suggested to the Board of Trade, as the result of trials made at the Imperial Institute, that Indian (*Bombax*) kapok might be used in place of Java (*Eriodendron*) kapok. The seed-hairs of *Calotropis procera*, known as akund floss, are also collected in India, and sometimes become mixed with Indian kapok. The results of trials at the Imperial Institute, details of which

are given in the following pages, showed that Indian kapok in a reasonably clean condition fully satisfies all the requirements of the Board of Trade as regards buoyancy and freedom from water-logging, but that akund floss, although meeting some of these requirements, will not stand rough usage and rapidly becomes water-logged, and therefore is unsuitable for use in life-saving appliances.

A full report on the experiments was furnished to the Board of Trade, who stated, however, that they are not prepared at present to allow Indian kapok to be used for life-saving appliances, and pointed out: (1) that it is liable to be adulterated with akund floss, (2) that no commercial standard for Indian kapok has been established, and (3) that no guarantee can be given that the commercial supplies used by manufacturers of life-saving appliances would be equal in quality to the sample tested at the Imperial Institute.

There is no reason why Indian kapok should not be obtainable in as clean a condition as Java kapok, provided that orders for definite quantities of the well-cleaned floss, free from akund, are placed with British firms trading in India. The Board of Trade suggest that if Indian kapok is obtainable commercially in a properly cleaned condition, and if their requirements as regards buoyancy appear likely to be fulfilled, they would be prepared to agree to an official test being carried out. There is no doubt that machine-cleaned Indian kapok similar to the sample examined at the Imperial Institute would pass the buoyancy test, and it therefore only remains to be demonstrated that supplies of the kapok equal in quality to this sample could be supplied commercially.

The Imperial Institute has communicated on the latter point with a firm of kapok merchants in London, who state that there should be no difficulty in obtaining commercial supplies of Indian kapok equal to the samples experimented with, and in order to obtain information on this point the Director-General of Commercial Intelligence in India has been asked to report on the subject.

Results of Trials at the Imperial Institute

The materials used in the experiments were as follows:

I (*a*) "*Machine-cleaned* [Indian] *Kapok.*"—Weight, 112 lb. Two bales of fine, lustrous, soft, curly floss of dark cream colour; the material was free from seeds and plant debris and compared favourably in this respect with commercial Java kapok of good quality.

II (*a*) "*Machine-cleaned Akund.*"—Weight, 67 lb. A bale of very lustrous straight floss of pale yellowish-brown colour and free from seeds and plant debris.

The amounts of moisture and ash in the samples of Indian kapok and akund floss and in a sample of Java kapok were determined for comparison, with the following results:

	Indian kapok. *Per cent.*	Akund floss. *Per cent.*	Java kapok. *Per cent.*
Moisture	8·1	7·9	9·0
Ash in dry floss	4·4	4·9	1·3
" " after washing the floss in boiling water	2·7	1·5	1·0

It will be seen, from these figures, that the Indian kapok and akund floss contain a much larger percentage of ash than the Java kapok. It was found that a large proportion of the ash in the two former cases consisted of very fine sand, some of which was removed by washing the floss in boiling water, but even after this treatment the Indian kapok still yielded 2·7 per cent. of ash as compared with 1·0 per cent. in the Java kapok and 1·5 per cent. in the akund floss. The samples of Indian kapok and akund floss, therefore, appear to contain a small quantity of very finely divided sandy material, the amount of which could probably be reduced by more care in the preparation.

(A) *Results of Small-scale Buoyancy Trials*

With a view to ascertaining the buoyancy of Indian kapok and akund floss in comparison with that of genuine Java kapok, the following small-scale trials were first made.

(1) A preliminary trial was conducted with 4-oz. samples of each floss contained in cotton bags; the cotton bags used for the tests were found to be unsatisfactory, owing to the fabric having been dressed, but

the results are quoted for comparison with later experiments. The following results were obtained:

	Weight required just to sink bags containing 4 oz. of floss.	
	Immediately after immersion.	24 hours after immersion with 3 lb. weight attached.
	oz.	oz.
Java kapok	92	83
Indian kapok (machine-cleaned)	106	101
Akund floss (machine-cleaned)	88	73

These preliminary tests indicated that the sample of Indian kapok was not inferior, but in fact rather superior in buoyancy to good Java kapok. The akund floss proved, however, to be somewhat inferior, and appeared to lose its buoyancy during immersion more rapidly than either Indian kapok or Java kapok.

In filling the bags for this experiment, it was noticed that the Indian kapok was more bulky than the Java kapok; the 4 oz. of Indian kapok had to be firmly compressed in order to get it into the bag, whilst the same weight of Java kapok could be placed easily in a bag of the same size without compression. This result is not in agreement with the observations made by an investigator whose report was transmitted to the Imperial Institute by the Board of Trade in September 1916, in which report the following statement is made:

"Accepting Java kapok as a standard for the measurement of natural volume per weight of kapoks, we have the following:

"Java 100

"No. 1 stows in 68 per cent. of the space occupied by the same weight of Java.

"No. 2 stows in 67 per cent. of the space occupied by the same weight of Java.

"This proves the Indian kapok to be inferior in natural volume per weight to the Java."

It may be mentioned that the sample described as "No. 1" consisted of commercial Indian kapok obtained in London, whilst "No. 2" was the same material after ginning at the Imperial Institute to remove impurities.

In order to investigate further this question of the natural volume of Indian kapok as compared with that of genuine kapok, the following experiment was made: 50 grams of floss was placed in a cylindrical glass jar, a light stiff cardboard disc was then laid on the floss and a 500-gram weight placed on the card; after standing some time, the height of the column of floss was measured. The following figures were obtained as a result of repeated experiments:

	Natural volume.
Java kapok	100
Indian kapok (machine-cleaned)	125
,, ,, (commercial sample No. 1, referred to above)	93
Akund floss	100

From the above figures it appears that the sample of commercial Indian kapok, No. 1, is inferior in natural volume to the machine-cleaned Indian kapok received at the Imperial Institute, but that the latter is more bulky, weight for weight, than a sample of genuine Java kapok of good quality examined for purposes of comparison. The sample of Java kapok used in these tests may not have been of identical quality with that used in the Board of Trade experiments mentioned above, but it seems unlikely that genuine Java kapok will show a very wide variation in natural volume.

(2) Further small-scale trials were made in which the conditions more nearly conformed to the requirements in the Board of Trade (Marine Department) Circular No. 1572, *Instructions to Surveyors: Life-jackets*, issued in April 1916, in which it is stated (page 2) that:

(*a*) Life-jackets intended for use by adults must be capable of supporting 15 lb. of iron in fresh water for 24 hours.

(*b*) At least 24 oz. of kapok must be in each life-jacket whose buoyancy is derived from this material.

(*c*) The material used for the cover must be unglazed and unmangled and free from all dressing.

The following further experiments were therefore made at the Imperial Institute, using unbleached cotton bags which had been thoroughly washed in boiling soap and soda solution to remove the dressing. The following results were obtained:

Sample tested.	Weight required to sink a bag containing 4 oz. of the floss in fresh water.							Calculated weight supported by 24 oz. of floss after 24 hours' immersion with 15 lb. of iron attached.
	A. Immediately after immersion.	B. After 24 hours in water with 40 oz. of iron attached.	Weight of water absorbed after Experiment B.	C. After rough treatment following Experiment B.	Weight of water absorbed after Experiment C.	D. After rough treatment and 44 hours' further immersion with 40 oz. of iron attached.	Weight of water absorbed after Experiment D.	
Eriodendron anfractuosum;	oz.	oz.	oz.	oz.	oz.	oz.	oz.	lb.
Commercial Java kapok Experiment (1)	83	87 [1]	3·0	70	—	68	22·4	32·6
Commercial Java kapok ,, (2)	82	91 [1]		52		63 [1]		34·1
Togoland kapok . . .	78	78	—	56	—	49	—	29·3
Bombax sp.:								
Indian kapok (I) (*a*) Machine-cleaned in India) Experiment (1)	99	97	3·0	77	—	70	—	36·4
Indian kapok (I) (*a*) Machine-cleaned in India) ,, (2)	107	107		52	—	58 [1]	28·3	40·1
Calotropis sp.:								
Akund floss (II) (*a*) Machine-cleaned in India) Experiment (1)	80	69	14	12	44	(Sank with less than 40 oz. of iron attached)	—	25·9
Akund floss (II) (*a*) Machine-cleaned in India) ,, (2)	74	45	—	8	—		—	16·9

[1] *These increases in buoyancy after immersion and after immersion following rough treatment are curious: they are not due to the canvas bag becoming impervious to air (owing to the water) and acting as an air vessel.*

The following observations may be made as a result of these small-scale trials:

(1) The machine-cleaned Indian kapok is superior in buoyancy to genuine Java kapok, both immediately after immersion (*A*) and after 24 hours' immersion (*B*). The results obtained after rough treatment are irregular (as might be expected from the fact that it is impossible to regulate exactly the violence employed in different tests), but the Indian kapok does not appear to be markedly inferior to Java kapok in its resistance to rough treatment.

(2) Akund floss is inferior both to Java kapok and to Indian kapok. Although the original buoyancy of akund floss is good, it loses its buoyancy fairly rapidly during immersion, absorbs water more readily than Java kapok or Indian kapok, and does not withstand rough treatment well.

Since this investigation was undertaken, the first requirement quoted from the Board of Trade regulations on page 18 has been altered as follows (*Circular* 1585, *Marine Department, Board of Trade*): "A life-jacket whose buoyancy is derived from kapok must be capable of supporting at least 20 lb. of iron after floating in fresh water for twenty-four hours with 15 lb. of iron attached." This modification has been introduced to exclude kapok adulterated with other flosses, and to avoid the necessity of microscopic examination to detect such adulteration. The machine-cleaned Indian kapok easily satisfies the new requirement, but the akund floss gave variable results in the two trials made with it, and in one case failed to pass the present test.

(B) *Results of Large-scale Buoyancy Trials*

In order to ascertain whether the results given by the foregoing small-scale experiments with 4-oz. samples of floss would be confirmed when using larger quantities such as those employed in life-belts, trials were made at the Imperial Institute with samples of 24 oz. of floss. The floss was placed in thin muslin, which had been previously washed to remove any dressing, instead of in cotton canvas bags, thus eliminating as far as possible

the influence of a more or less dense fabric such as cotton canvas.

The results are given in the following table, in comparison with figures calculated from the results of the small-scale trials :

Sample tested.	Weights of iron supported by 24 oz. of floss in fresh water.						
	A. Immediately after immersion.	B. After 24 hours with 15 lb. iron attached.	Weight of water absorbed.	C. After rough treatment following Experiment B.	D. Further immersion with 15 lb. iron attached. 24 hours.	D. Further immersion with 15 lb. iron attached. 44 hours.	Weight of water absorbed after Experiment D.
	lb.	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*
Java kapok: commercial sample; 24 oz. of floss used	30·3	31·5	0·94	24·3	19·5	—	10·3
Calculated for 24 oz. of floss from results of small-scale trials	30·9	33·3	1·13	19·5 [1]	—	23·6 [1]	8·4
Indian kapok (machine - cleaned): 24 oz. of floss used	45·5	42·3	1·0	29·5	18·0	—	12·5
Calculated for 24 oz. of floss from results of small-scale trials	38·6	38·2	1·13	19·5 [1]	—	21·7 [1]	10·6

[1] *Lowest figures obtained.*

It will be seen that the results obtained on a large scale with 24-oz. samples of floss agree well with those obtained in the small-scale trials, except in the case of the weights supported by the floss after rough treatment. It is, however, impossible to obtain concordant results in these tests owing to the difficulty of regulating the treatment in different experiments.

Remarks

Although Indian kapok appears to be liable to contain more adventitious matter (*e.g.* sand, leaf and pieces of pod) than commercial Java kapok, there is no apparent ground for condemning its use in life-saving apparatus provided that it is in a reasonably clean condition. In the present experiments even though the machine-cleaned Indian kapok contained some fine sand, it was superior

in buoyancy to genuine Java kapok of good quality, and fully satisfied the requirements of the Board of Trade regulations.

Akund floss, on the other hand, is distinctly inferior to kapok in buoyancy, and in one of the trials its buoyancy after twenty-four hours' immersion was not sufficient to meet the Board of Trade new requirements ; further, it will not stand rough usage, and rapidly becomes water-logged. It should, therefore, be excluded from use in life-saving appliances and its use restricted to upholstery, etc., where buoyancy is not required.

TRIALS OF SUDAN DURA FOR BREWING

Dura, a form of millet, known in India as dari and in South Africa as kaffir corn, is the grain of *Sorghum vulgare*, a grass widely cultivated in tropical and sub-tropical countries. The grain is used locally by the natives as a food-stuff and to some extent in Europe for feeding poultry and livestock, and as a substitute for maize in distilling. The imports of the grain into the United Kingdom during the five years 1912–16 ranged from 10,000 to 20,000 tons per annum. No country grows the crop specially for export, and supplies have to be obtained from wherever a surplus is available for shipment. For this reason the imports into the United Kingdom from the different producing countries fluctuate from year to year. In 1912, for example, out of a total import of 14,000 tons, 11,000 tons came from Asiatic Turkey; in 1913 the United States supplied 15,000 tons out of a total import of 17,000 tons ; and in 1915, when the imports reached a total of 20,000 tons, India supplied a little more than half this quantity, the remainder coming chiefly from South Africa, Egypt and Japan. In 1914, when just over 10,000 tons were imported, the bulk was supplied by India, Java and Asiatic Turkey, whilst in 1916 most of the 11,000 tons imported came from South Africa, Egypt, the United States and India.

Large quantities of dura are produced in the Sudan, but hitherto only small quantities have reached the

United Kingdom from that country, 2,500 tons being exported here in 1915, just under 900 tons in 1916, and 500 tons in 1917. In 1915 Sudan exported altogether 46,000 tons of dura, of which 20,000 tons went to Eritrea, 15,000 tons to Arabia and 6,000 tons to Egypt; in 1916, 57,000 tons were exported, 24,000 tons going to Egypt, 19,000 tons to Eritrea and 11,000 tons to Arabia; in 1917, the record quantity of nearly 85,000 tons was exported, 80,000 tons of which went to Egypt. At the present time the export of dura from Sudan is controlled by Government.

In order to ascertain the value of Sudan dura as a feeding-stuff for livestock, the Imperial Institute supplied a large quantity of the grain to the Agricultural Department of Durham University. Experiments were conducted with the dura in comparison with maize as a food for milch cows, and the conclusion was reached that the former might be used with advantage as a substitute for maize. Similar trials were also conducted at the South Eastern Agricultural College, Wye. In this case also the dura was fed with satisfactory results to milch cows, whilst the cracked or "kibbled" grain was readily eaten by sheep, and it was considered that it would perhaps be specially useful for fattening sheep in winter. An account of these feeding experiments was given in this BULLETIN (1913, **11**, 37). The same article (p. 36) also gives the results of preliminary trials conducted by manufacturers and others in order to ascertain the value of dura for the manufacture of starch and glucose, and for distilling and brewing. In August 1916 Messrs. Lawrence Briant and Harold Harman were consulted by the Imperial Institute as to the suitability of Sudan dura for brewing purposes. The results of their preliminary experiments were promising, and in May 1917 some 5 to 6 tons were placed at their disposal in order that experiments on a large scale might be carried out. Messrs. Briant and Harman furnished a report on the results of their investigation which is reproduced in the following pages, supplemented in details to some extent by information contained in a paper by these authors published in the *Journal of the Institute of Brewing* (1918, **24**, 209).

A preliminary analysis and examination of the material led Messrs. Briant and Harman to think it likely that the dura might be of use in the following directions:

1. As malt.
2. As roasted grain for colouring and flavouring purposes, with or without preliminary germination.
3. As flakes.
4. As glucose.

1. *Dura Malt*

Preliminary tests indicated that the grain germinates quite freely, and at Messrs. Briant and Harman's request, maltsters of experience consented to make a trial under practical conditions, dealing with a little over 1½ tons of the material.

The dura is not easy to handle during germination, because, owing to the absence of the outer and protecting skin—which is present on barley—the acrospire is exposed, and is very liable to be injured and detached during the frequent moving of the grain which is a necessary part of the malting process. This increases the practical difficulty in dealing with the material.

Two batches of malt were made. In each case the malt was fairly tender, had acquired good flavour on curing, and though with the first sample the curing was found to be at fault, in the second this was remedied, and the material gave the following figures on analysis, compared with an ordinary barley malt:

		Malted dura.	Malted barley.
Extract per quarter of 336 lb.	*saccharometer lb.*	29·9	93·0
Moisture	*per cent.*	3·2	2·5
Colour of 20-lb. wort (Lovibond's Tintometer)		14°	14°
Diastatic power (in degrees Lintner)		24°	30°
Matter soluble in cold water	*per cent.*	12·6	18·0

The analysis shows that there has been quite good development of enzymic activity, as represented by diastatic power, and the figures are normal to malt except in respect to extract, which is disappointing. Since dura contains about 60 per cent. of starch substance, the poor extract must be due either to imperfect modification of the starch cells during malting, or to some substance interfering with the enzymic action when the malt is

extracted. The authors consider that the latter is not likely, as an investigation carried out by the Imperial Institute has proved that no such substances are present.

As mentioned above, the malted material possesses fair tenderness, and such tenderness generally denotes satisfactory yield of extract on mashing, though it does not do so in this case.

A number of experiments were made—the details of which it is not necessary to give—and these convinced the authors that under certain conditions malted dura would give an extract of about 92 saccharometer lb., but they think it likely that in practice it might be extremely difficult to secure this.

2. (*a*) *Roasted Grain*

Barley is now roasted for the purpose of making what is known as "roasted barley," which is used for flavouring and colouring purposes. It is also roasted after partial malting, and is then known as "black malt." Roasted barley is used for the colouring of dark mild and black beers which are intended for moderately quick consumption. Black malt is used for dark coloured beers, which are expected to keep for a long time.

Experiments in the roasting of malted and unmalted dura have been made by malt roasters, and the material was found to give the following figures—those of roasted barley being added for comparison :

	Roasted after malting.	Roasted raw.	Roasted barley.
Extract per 336 lb. . . *lb.*	83·5	87·0	80·0
Colour :			
0·2 per cent. solution in 1-in. cell	25°	27°	30°
10 ,, ,, ,, ,,	1250°	1350°	1500°

These are very good results, and the material acquired quite a satisfactory aroma and flavour, and appeared likely to compare quite favourably with the coloured material made from barley. There is always a considerable loss in weight in the roasting operation. This loss was in the first experimental working found to be excessive, but, after adjusting the process, it was found to be practically the same as when roasting barley.

A sufficient quantity of roasted material being obtained,

some London brewers were requested to use it in the brewing of porter, and this was done.

Two comparative brewings were made, in which the only difference in the blend of grist used was that 10 per cent. of the roasted barley in the first brewing was replaced by 7 per cent. of the roasted dura. The lower percentage of the dura was arranged because its flavour was a good deal stronger than ordinary roasted barley, and it seemed likely that both in colour, and in the all-important flavour, 7 parts of the roasted dura would be equivalent to 10 parts of the ordinary roasted barley.

The resulting beers were very carefully tested for flavour at the brewery, and independently by the authors. As regards colour, the porter brewed with the dura had a better colour than that brewed with the roasted barley, in spite of the smaller proportion used. As regards flavour and general character, the brewery expert opinion was that the palate of the beer brewed with the roasted dura was in no way inferior to that brewed with roasted barley, and Messrs. Briant and Harman's opinion confirms this.

A second practical test is being made, and the authors state that they will shortly be able to report on any possible difference in stability or palate of the beer after it has matured.

These experiments prove that roasted dura will replace roasted barley in the portion of 7 of the former to 10 of the latter, without interfering with the character of the beer in which it is used.

2. (*b*) *Roasted Malted Grain*

The flavour of this proves to be quite good, but the extract yield and colour value are low, and the authors are not of opinion that the flavour of the malted material would in practice be worth the trouble of malting.

2. (*c*) *Amber Malt* (*partially roasted material*)

Two tests were made in the production of this material, and both the maltsters and Messrs. Briant and Harman were of opinion that its flavour was excellent. Unfor-

tunately the extract yield is very low. This is, however, no doubt caused by the difficulty of proper malting, to which reference has already been made, and, could that be overcome, it is believed that amber malt yielding a satisfactory extract could be obtained.

The following are the figures of the two batches made, with those of amber malt placed side by side for comparison :

	1st Test.	2nd Test.	Amber malt.
Extract per 336 lb. . . . *lb.*	20·0	19·5	78·0
Colour :			
2 per cent. solution in a 1-in. cell .	15°	15°	40°
10 ,, ,, ,, ,, .	75°	75°	200°

It should be added that, as amber malt is used primarily for flavour, some shortage of extract would not necessarily be an insuperable bar to the use of dura for this purpose.

3. *Flakes*

Flaked material used in brewing is made from maize or rice, chiefly the former. Flaked barley is not considerably employed. A firm of flake manufacturers consented to experiment, and the results are very encouraging.

The flaking process is easily carried out, and the starch gelatinises without difficulty, but the appearance is not so attractive as that of maize or rice—though this is not an important matter—and the flakes are somewhat brittle in character, a drawback, as they are generally trans-shipped in sacks, and a good deal of dust would probably be produced, which might interfere with drainage when used with malt in the mash tun.

In the manufacture of flakes there is inevitably some meal separated, which cannot be sold as flakes, but could easily be utilised for glucose making, or as a feeding stuff. The average outcome of flakes from maize is about 68 per cent., and where the germ is not removed, for example in flaked rice, it is about 95 per cent. In the dura experiment the outcome was about 80 per cent., and the meal about 15 per cent.

An analysis of this meal gave the following figures:

	Per cent.
Starch and digestible carbohydrates	55·76
Albuminoids	14·44
Oil	8·00
Ash	6·98
Cellulose (woody fibre)	4·90
Moisture	9·92
Food unit value	111·86

Although the ash and woody fibre are a little high, the meal is an excellent cattle food, and it is satisfactory that about two-thirds of the oil in the dura comes out in the meal, leaving only 1·3 per cent. in the flaked material.

The figures of analysis are as follows:

		Flaked dura	Flaked maize.
Extract per 336 lb.	*lb.*	94·4	100–102
Oil	*per cent.*	1·3	1·2
Moisture	,,	7·6	7·6

The extract is necessarily lower than that of maize on account of the smaller percentage of starch content in the material, but it would appear that the full extract value is yielded by the flaking process. The character of the extract is quite satisfactory, closely resembling that obtained from flaked rice.

Sufficient flakes were manufactured to enable the authors to put through comparative brewings. As it was not possible—and perhaps not advisable—to replace the whole of the flaked maize in the grist by flaked dura, a bitter beer or pale ale was brewed in which about half the usual percentage of flaked maize—15 per cent.—was replaced by flaked dura—*i.e.* 7 per cent. The resulting beer was quite satisfactory, and the brewing expert's opinion was that dura flakes are at any rate equal to those from maize.

In the actual brewing the use of dura interfered a little with the normal drainage in the mash tun, but this interference was so slight that the brewer stated that he would have no hesitation in risking the use of all flaked dura instead of only half, as used in this particular case.

Whilst Messrs. Briant and Harman corroborate the opinion of the brewery that there was little to choose in flavour between the two beers, they are of opinion that the flaked dura gives a beer of rather drier character

than flaked maize; but this is a matter of very little consequence, as in many cases such character is preferred, particularly in the brewing of bitter beers or pale ales.

The employment of dura in brewing as flakes is considered to be quite practicable, and it largely resolves itself into a question of cost, dura giving a lower yield than either maize or rice.

It might be mentioned that there seems no reason why flaked dura should not make a satisfactory cereal food for direct human consumption.

4. *Glucose*

Very promising results have been obtained from the first batch of material which has been treated. The amount available at the time of the first experiment was not large enough to permit of an entirely satisfactory works test, but the yield obtained was considered to be quite good for this class of material.

The manufacturers reported that the seed was first ground to flour, and then acted upon by acid in the usual way; that the conversion was slow, and that it was difficult to convert completely the dextrin at first formed into the final product of glucose. From the brewing point of view, however, this is of no serious consequence, because glucoses of dextrinous type have their own particular value in connection with the brewing of special beers, and the authors were decidedly impressed with the character of the sugar.

The following are the analytical figures:

		Per cent.
Sugars fermentable in primary fermentation	Dextrose	39·70
	Maltose	9·18
Other carbohydrates, dextrin, etc.		32·42
Protein		2·00
Mineral matter		1·44
Water		15·19
Extract per 112 lb.		37·3

These figures are quite satisfactory, the glucose is of good flavour, and would be satisfactory as brewing material.

It should also be quite serviceable for jam making,

and other purposes in which glucose from maize is now used.

Preliminary experiments being satisfactory, it was decided that the remaining 2 tons of dura available should be converted into glucose, and a practical test made in a brewery.

The sugar so obtained was of malto-dextrin type, and some beers were brewed in which dura sugar was compared with invert both in the copper and as priming.

The resulting beers were carefully examined and it was concluded that, in new bitter beers, the dura sugar gave a decidedly better character than did invert sugar; but with new mild ales the dura sugar gave beers of rather less fulness than invert sugar.

The samples were gone through again after three or four weeks' storage, and it was unanimously agreed that the dura beers—both those brewed and primed with this sugar—had more character and better quality in all respects than the invert beers, and that when the original gravity of the beer was increased by an addition of dura sugar as priming, the primed beer possessed fully the palate of its increased gravity.

It should be mentioned that when the sugars were compared by examination of the new beers, many of those containing dura sugars were inferior partly because the amount of invert experimentally used as priming was obviously excessive for bitter beers.

Conclusions

Messrs. Briant and Harman consider that the results of their experiments and all the practical trials which have been made show that, if sufficient dura is obtainable at a suitable price, it can be quite successfully employed in the manufacture of roasted grain as a substitute for roasted barley, as flakes, or as sugar of malto-dextrin type.

For some purposes it would be an advantage, in the production of glucose, to push the starch conversion process a stage further, producing a solid glucose in place of the malto-dextrin type, and certainly, if a quantity of this material could be liberated for use in brewing purposes, it would ease the situation at the present time, and do

something to correct the general grain shortage which exists, whilst in the future, as a competing and alternative material, it might prove very useful.

The outlook for the malting of dura is not so hopeful, but it must be remembered that the malting of wheat gave initial difficulties when it was started, and it is believed, if further material were available, more successful results might be obtained, though it is never likely to compete with barley as malt material.

THE INDIGO OF NIGERIA AND ITS VALUE AS A DYE

THE native indigo plant of West Africa, *Lonchocarpus cyanescens*, Benth. (Nat. Ord. Leguminosæ), yields under suitable conditions the same blue dye, indigotin, as the ordinary indigo plant (*Indigofera* spp.), and is largely used by the natives in dyeing. In Abeokuta in the Southern Provinces of Nigeria, there are plantations of the plant extending to several hundred acres (*New Bulletin, Additional Series* IX (1911), p. 245); but, as a rule, the leaves and young shoots are collected from wild plants, which are, however, commonly preserved by clearing away the surrounding scrub. In its natural state the plant is a climber, reaching a height of 30 ft.; but under cultivation it becomes a bush 7 or 8 ft. high, owing to the regular cutting.

The usual native method of dealing with *L. cyanescens* is to pound the fresh leaves and make the mass into balls about 4 inches in diameter, in which condition the dyestuff is stored until it is required, or the leaves may be simply broken up and allowed to dry in the sun. In dyeing with this plant the prepared material is soaked in water for about 12 hours and the yellowish liquid so produced is decanted and thrown away, the wet residue being allowed to ferment for two or three days. During this period of fermentation powdered root bark of the "brimstone" tree (*Morinda citrifolia*) is added, together with some potash. Water is eventually added to the mixture, together with a decoction of the Morinda bark and more potash. At this stage the mixture is left exposed

to the sun all day and stirred from time to time, but is covered up at night. After about nine days the dye bath is ready for use, and the fabric to be treated is thrown in, moved about in the liquid, left there for some time, and then dried in the sun. This operation is repeated until the required shade of blue is obtained.

Specimens of the dried plant from Sierra Leone and the Southern Provinces, Nigeria, examined at the Imperial Institute some years ago, were found to yield 0·65 per cent. of indigotin (this BULLETIN, 1907, **5**, 129; 1909, **7**, 319), whilst a sample of lump indigo prepared from the plant by natives of Kontagora, Northern Provinces, Nigeria, (*ibid.*, 1909, **7**, 319) gave only a low yield of indigotin, viz. 21·5 per cent., as compared with 60 per cent. in good commercial Bengal indigo derived from *Indigofera* sp. A further specimen of indigo from Nigeria examined in 1917, the botanical source of which was not stated, was also of rather low grade, containing 27·5 per cent. of indigotin (*ibid.*, 1918, **16**, 11); but in this case the yield was reduced owing to the presence of a large amount of mineral matter in the sample.

In order to determine the yield and quality of indigo which *L. cyanescens* will furnish, a series of experiments was conducted recently in the Southern Provinces, Nigeria, and ten samples of indigo were forwarded to the Imperial Institute for examination last year. Details of the experiments and of the samples submitted are given below.

Experiment I.—This was carried out by the method usually employed in India; 110 lb. of fresh leaves were used and three fractions of indigo were obtained as follows:

	Yield of dried paste. Oz.
Sample I. (*a*) 1st extraction (16 hours' fermentation)	1·0
„ „ (*b*) 2nd „ (24 „ „)	0·5
„ „ (*c*) 3rd „ (24 „ „)	0·5

The total yield of indigo obtained was equivalent to 1·82 oz. from 100 lb. of fresh leaves.

Experiment II.—In this experiment ammonia was added to the liquor before beating until the mixture smelt faintly of ammonia. The separation of the indigo was much more rapid, but the precipitate was so finely divided that it did not settle in 24 hours, and would not flocculate

on boiling. The liquid was, therefore, evaporated to about one-third of its volume and strained; the paste thus obtained was thought to be superior, in appearance at least, to that obtained by the ordinary method. In this case also 110 lb. of fresh leaves were used, and the indigo was separated in three fractions as in Experiment I.:

	Yield of dried paste. *Oz.*
Sample II. (*a*) 1st extraction (16 hours' fermentation) . .	2·75
,, ,, (*b*) 2nd ,, (24 ,, ,,) . .	1·00
,, ,, (*c*) 3rd ,, (24 ,, ,,) . .	0·25

The total yield of indigo obtained by this process was equivalent to 3·64 oz. from 100 lb. of fresh leaves.

Experiment III.—No special treatment was employed in this experiment; 285 lb. of fresh leaves were used, and the indigo was separated in two portions as follows:

	Yield of dried paste. *Oz.*
Sample III. (*a*) 1st extraction (16 hours' fermentation) .	3·25
,, ,, (*c*) 2nd ,, (24 ,, ,,) .	1·50

The total yield of indigo was equivalent to 1·67 oz. from 100 lb. of fresh leaves.

Experiment IV.—In this experiment an attempt was made to extract the indigo from 32 lb. of dry leaves (equivalent to 141 lb. of fresh leaves), but the results were not satisfactory. A yellowish liquor resulted from which no indigo could be obtained by beating or by boiling. On addition of ammonia the liquid immediately became turbid and of brownish-black colour; after concentration of the liquid the precipitate was separated by straining, and dried. The yield of dried paste (Sample IV) was 4½ oz.

Experiment V.—Ammonia was used in this experiment, sufficient being added to make the liquor strongly alkaline, more so than in Experiment II. In this case the liquor with the precipitate in suspension was of a pronounced brownish-purple or maroon colour, instead of the rich blue colour previously obtained. The yield of dried paste (Sample V) was 2 oz.

The samples were chemically examined at the Im-

perial Institute, with the results shown in the following table :

Sample.	Weight.	Description of Sample.	Moisture.	Ash.	Indigotin.
	Oz.		*Per cent.*	*Per cent.*	*Per cent.*
I (*a*) 1st extraction	¾	Bright, deep blue colour, strong coppery lustre; slightly mouldy	3·7	5·1	56·3
,, (*b*) 2nd ,,	½	do. do.	3·9	4·7	50·8
,, (*c*) 3rd ,,	½	Deep blue, fairly bright, strong coppery lustre; slightly mouldy	5·8	10·2	43·2
Ammonia Indigo: II (*a*) 1st extraction	1¾	Deep blue with a violet tint, strong coppery lustre	6·3	13·8	45·0
,, (*b*) 2nd ,,	½	Strong, dull blue, strong coppery lustre	6·2	7·0	38·6
,, (*c*) 3rd ,,	¼	Similar to II (*b*), but rather duller	6·4	7·1	31·9
III (*a*) 1st extraction	2¾	Strong, dull coppery blue, with strong coppery lustre	6·3	7·3	42·9
,, (*b*) 2nd ,,	1½	Dull brownish- or bluish-black, slight coppery lustre	9·1	12·1	5·5
IV. Extracted from dry leaves	4½	Brownish-black, rather soft and damp, no coppery lustre	20·1	20·5	nil
V. Ammonia indigo: Beating vat strongly ammoniacal	2	Brownish-black, no coppery lustre	10·0	25·0	nil

The above figures indicate that the method employed in Experiment I, viz. the treatment usually adopted in India, yields indigo containing the largest proportion of indigotin, the amount ranging from 43·2 to 56·3 per cent. Sample I*a* contains the most indigotin (56·3 per cent.) in the series and compares favourably with good Bengal indigo which usually contains about 60 per cent. All three samples obtained in Experiment I are superior to average Madras indigo, which contains about 30 per cent. of indigotin.

The ammoniacal treatment adopted in Experiment II furnishes indigo containing much less indigotin, viz. from 31·9 to 45·0 per cent.; but it must be noted that in this

case the yield of indigo paste was double that obtained in Experiment I.

Experiment III, in which no special treatment was adopted, gave a fairly good first fraction of indigo, containing 42·9 per cent. of indigotin, but the second fraction contained only 5·5 per cent., and would be worthless for dyeing purposes. The results obtained in this experiment were therefore not so good as those in Experiment I.

Samples IV and V contained no indigotin.

The percentages of indigotin in the samples obtained in Experiments I, II and III*a* can be considered as satisfactory. Practical trials with well-prepared samples of *Lonchocarpus* indigo would, however, be required in order to establish its technical and commercial value in comparison with the grades of natural indigo derived from cultivated species of *Indigofera*. The present samples were insufficient for dyeing trials or for commercial valuation.

The amount of ash in the samples (excluding IV and V) is fairly satisfactory, ranging from 4·7 to 13·8 per cent. Best quality Indian indigo contains as little as 3 per cent. and inferior grades as much as 30 per cent. of ash.

The yields of indigo obtainable from species of *Indigofera* cultivated in India vary considerably according to the variety of plant, the nature of the soil and the conditions of cultivation and manufacture. The following figures of yields obtained by a number of indigo factories and by the Sirsiah Indigo Research Station in Bihar will be of interest for comparison with the yields obtained from *Lonchocarpus cyanescens* in Nigeria :

Year.		Variety of plant.	Yield. Oz. of 60 per cent. indigo per 100 lb. of green plant.
1906	Average yield of 20 factories	Java indigo	5·9
		Sumatrana indigo	4·9
	Sirsiah Station	Java indigo	6·8
1907	Average yield of 31 factories	Java ,,	6·0
	Sirsiah Station	Java ,,	6·4

In 1916 the average yield of indigo obtained at factories in Bihar from 100 lb. of green plant was 3·2 to 3·6 oz. from the Sumatrana variety and 6·4 to 7·2 oz. per 100 lb. from the Java variety.

The yield of indigo obtained from *Lonchocarpus*

cyanescens in the present experiments and the percentages of indigotin are shown in the following table:

	Total yield of indigo. Oz. per 100 lb. of fresh leaf.	Percentage of indigotin (average).
Experiment I	1·8	52
„ II	3·6	43
„ III (*a*)	1·1	43

It will be seen from these figures that the yields are not equal to those obtained from species of *Indigofera* in India. Moreover, these yields from *Lonchocarpus* are from the leaves alone, whereas those given for *Indigofera* spp. in India are from the green plants, of which only 40 to 50 per cent. consists of leaves.

In Experiment II the yield is similar to that obtained from the Sumatrana variety of indigo in India, but the percentage of indigotin is only 43 per cent. as compared with 60 per cent. in good commercial Indian indigo.

The results of this investigation indicate that indigo of good quality containing up to 56 per cent. of indigotin can be prepared from the fresh leaves of *Lonchocarpus cyanescens*. The indigo of best quality was obtained by the use of the usual method employed in India, but the yield was much less than that obtained in India from green plants of *Indigofera* spp.

The use of ammonia in Experiment II apparently produced a larger yield of indigo, assuming that the leaf used in the two experiments was of similar quality, but the product contained less indigotin. It is noteworthy, in this connection, that the product obtained in Experiment V, in which an excess of ammonia was used, contained no indigotin. Further investigation would consequently be necessary before a definite conclusion as to the influence of the ammonia could be safely drawn.

Mr. W. A. Davis, B.Sc., Indigo Research Chemist to the Government of India, has pointed out that the use of "Dhak gum," a variety of kino derived from *Butea frondosa*, greatly facilitates the settling of the indigo and considerably increases the yield. It is possible that the kino furnished by species of *Pterocarpus* in Nigeria may have a similar effect, and it would be worth while to conduct experiments in this direction in Nigeria. Mr. Davis states (*Indigo Publication* No. 3, 1918, *Agric. Res. Inst.*,

Pusa), that Dhak gum is used in the proportion of 1 seer of gum per 100 maunds (about 1 oz. per 250 lb.) of plant. Each seer is soaked in a bucket of water overnight to soften it, and the water is then raised to the boil to dissolve the gum. The liquor is strained through a cloth and sprinkled on the surface of the beating vat about 5 minutes before beating is ended. The action of the beating wheel is then continued for 5 to 6 minutes to ensure thorough mixing, and the mal is then left to settle in the usual way. Increase of produce of 3 to 6 seers of cake indigo per 100 maunds (1·2 to 2·4 oz. per 100 lb.) of plant has actually been obtained at several factories by the use of Dhak gum. An increase of 6 seers of indigo represents an increase of about 70 per cent. with ordinary Sumatrana working, which gives only 8 to 9 seers of indigo per 100 maunds (3·2 to 3·6 oz. per 100 lb.) of plant worked, and of about 35 per cent. with Java plant. The use of Dhak gum does not cause any appreciable deterioration of quality.

SUDAN LETTUCE SEED AS A SOURCE OF OIL

Two forms of lettuce are grown as a vegetable on irrigated land in Egypt: the ordinary garden lettuce (*Lactuca sativa*) and the prickly lettuce (*L. scariola* var. *sativa*). The latter is similar in appearance to the cos lettuce of European gardens, and a form of it (*L. scariola* var. *oleifera*) is cultivated in Upper Egypt for its oily seeds, which are stated (Fletcher and Cartwright, *Egyptian Agriculture*, vol. ii. p. 562) to yield by expression 37–38 per cent. of an edible oil known by the Arabic name of "zeht helon" (= sweet oil). It has been suggested that the seed might be grown in certain parts of the Sudan to supplement the sesame crop, and, with a view to ascertaining its value as a source of oil, a sample was forwarded to the Imperial Institute from the Sudan in May 1918.

The sample consisted of small, dark greenish-brown pointed seeds about ⅛ in. in length. A quantity of foreign matter was present, chiefly green seed pods, broken leaf and pieces of stem.

The seed was found to contain 3·9 per cent. of mois-

ture and to yield 44·2 per cent. of oil, equivalent to a yield of 46·0 per cent. expressed on the dry seed.

The oil was clear, of bright yellow colour, almost odourless, and free from any unpleasant taste. It was submitted to chemical examination with the following results:

Specific gravity at $\frac{15^\circ \text{C.}}{15^\circ \text{C.}}$		0·9244
Solidifying point of fatty acids		17·2° C.
Acid value [1]		nil
Saponification value [1]		194·2
Iodine value	*per cent.*	125·2
Unsaponifiable matter	,,	1·5
Volatile acids, soluble [2]		0·6
,, ,, insoluble [2]		0·2

[1] *Milligrams of potash for 1 gram of oil.*

[2] *Cubic centimetres of decinormal alkali required to neutralise acid from 5 grams of oil.*

The oil dried slowly on exposure to air, but did not yield a tough film. When heated at 280° C. for 15 minutes it did not polymerise, and when mixed with "driers" and heated for some time it became only slightly viscous. It may therefore be classed as a "semi-drying" oil. Its constants closely resemble those of sunflower oil.

The residual meal left after the extraction of the oil was light grey, and had a slightly bitter taste. It was analysed with the following results, compared with those recorded for linseed and cotton-seed cakes and meals:

	Lettuce-seed meal.	Linseed.		Cotton seed.	
		Cake.	Meal (extracted).	Decorticated meal (expressed).	Undecorticated cake (expressed).
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	8·0	11·16	13·15	7·40	13·75
Total proteins	34·3	29·50	34·75	42·37	24·62
True proteins	27·7	—	—	—	—
Other nitrogenous substances	6·6	—	—	—	—
Fat	1·1	9·50	3·03	10·16	6·56
Starch (by difference)	34·4	35·54	34·67	25·86	29·28
Fibre	11·8	9·10	8·75	7·06	21·19
Ash	10·4	5·20	5·65	7·15	4·60
Nutrient ratio [1]	1:1·1	1:1·94	1:1·20	1:1·16	1:1·67
Food units [2]	123	133	129	157	107

[1] *The ratio between the percentage of crude proteins and the sum of the percentages of starch and fat, the latter being first converted into its starch equivalent.*

[2] *The total obtained by adding the percentage of starch to 2·5 times the sum of the percentages of fat and crude proteins.*

The lettuce-seed meal contained a trace of alkaloid but no substances yielding prussic acid. The percentage of proteins is high, and the meal compares favourably in feeding value with the linseed meal quoted in the above table.

The lettuce seed was submitted to a firm of oil-seed crushers, who stated that, owing to its small size, the seed would be difficult to handle and might prove awkward to crush in the ordinary machinery, but that under present conditions, there would be no difficulty in finding a market in this country for a considerable quantity. They considered that the oil would be worth £65 per ton (November 1918), and stated that it could be used as a soap-making oil, or possibly as a substitute for linseed oil in paint or varnish manufacture, etc.

The firm mentioned that it would probably not be possible to use the residual meal by itself as a feeding stuff, on account of its flavour, but that, assuming it to be harmless, it might serve as an ingredient in compound cakes, for which purpose its present value would be possibly about £16 per ton. On this basis the seed would be worth £30 per ton, delivered at United Kingdom ports.

The present investigation shows that lettuce seed furnishes 44 per cent. of a non-drying oil similar in character to sunflower oil. The oil possesses no unpleasant odour or taste, and might therefore prove to be suitable for edible purposes in addition to the technical uses already mentioned.

Feeding trials would be necessary in order to determine whether the meal could be safely used as a feeding stuff for animals.

There is no doubt that lettuce seed would sell readily as an oil seed in the United Kingdom at the present time if it could be shipped in commercial quantities, and the Imperial Institute has therefore asked for information as to supplies available in the Sudan.

GENERAL ARTICLE

COCOA PRODUCTION IN THE BRITISH EMPIRE

In the present article a comprehensive account is given of the present production of cocoa within the Empire. For the preparation of the groundwork of this article the Imperial Institute is greatly indebted to Mr. A. H. Kirby, Assistant Director of Agriculture in the Southern Provinces of Nigeria, who volunteered during his period of leave in this country during the war to give assistance in the work of the Institute, which was much hampered by the absence of staff on active service.

Mr. G. C. Dudgeon, C.B.E., formerly Inspector of Agriculture for British West Africa, has kindly given considerable assistance in revising certain sections.

I. Introduction

The name "cocoa" or "cacao" is that commonly applied in commerce to the fermented and dried seeds (usually termed "beans") taken from the fruits of three or more species of trees belonging to the genus *Theobroma*, and found in a natural state in Central America and the northern part of South America.

Since the Spaniards under Cortez first met with the produce of the cocoa plant in Mexico, and the subsequent spread of its employment as a beverage through Italy to France, Holland and England, when Venezuela had taken the place of Mexico as the chief producing country, the growing of the plant for commercial purposes has extended not only to other countries in the New World, such as Brazil, Ecuador, several of the West Indian Islands and Costa Rica, but to widely scattered areas in the Old World, such as San Thomé, the Gold Coast, Nigeria, Cameroons and the Belgian Congo in Africa, and Ceylon and the Dutch East Indies in Asia.

The importance of cocoa as a world's product is shown by the circumstance that in 1916 the production was nearly 300,000 tons. The countries that contributed chiefly to this production were, in order of importance, the Gold Coast, Brazil, Ecuador, San Thomé, Trinidad,

San Domingo and Venezuela, each responsible for a supply exceeding 14,000 tons.

Of the minor producing countries, the British West Indies, excluding Trinidad, exported nearly 10,000 tons in 1916, followed by Nigeria with about 8,000 tons, the German Colonies (chiefly Cameroons) with about 4,000 tons, and Ceylon with about 3,700 tons in that year. The chief countries taking a lower place than these in the cocoa markets of the world are Fernando Po, Java, Haiti, Cuba, the French Colonies (chiefly Guadeloupe and Martinique) and Dutch Guiana, which supplied between 1,500 and 3,300 tons in 1916. The Belgian Congo, Costa Rica and Colombia all had a production of less than 1,000 tons.

As has been indicated already, the oldest cocoa-producing countries are naturally situated in the New World, whence the product originally came, the early history of cocoa growing being bound up with the names of Mexico, Venezuela, Trinidad, Jamaica, Haiti and Martinique, followed by those of Ecuador and Dutch Guiana (Surinam). The production in these countries, however, has been surpassed by that of others, in some cases through their own decline as cocoa-growing countries, and in others through the more rapid growth of cocoa cultivation in other areas both in the New World and the Old. Mexico now produces a quantity insufficient for its own needs. A century ago, Venezuela was first among cocoa-exporting countries, to be surpassed fifty years later by Ecuador, which in turn has been displaced within the last decade by the Gold Coast.

Among other old cocoa-growing countries, Haiti, Dutch Guiana and Martinique (with Guadeloupe) have lost the importance they possessed many years ago. Progress in these countries gives scope for an interesting comparison with the phenomenal increase of production in the past twenty-five years that has taken place in the Gold Coast, Brazil, San Thomé and San Domingo, where an output, in no case exceeding 5,600 tons in 1890, has given place in every instance to a present export of more than 20,000 tons.

Among the countries of greatest export Trinidad may be taken, with Venezuela, as an old cocoa-producing

country which has been steadily increasing its output during recent years; whilst the Gold Coast, which has increased its output more than a hundredfold since 1900, affords the most striking example of quick development of cocoa cultivation in any country where this product is grown.

Referring to the consumption of cocoa, the United States and Germany have been easily first, the former consuming 66,500 tons in 1913, and the latter about 50,000 tons. Holland, the United Kingdom and France come next, with about 27,000–28,000 tons each; Switzerland needed only 10,000 tons, and Spain, Austria-Hungary, Belgium, and Russia only a little more than 5,000 tons each; other countries together took more than 13,000 tons, bringing the world's consumption in 1913 to nearly 250,000 tons.

The chief factor which has led to the present enormous consumption of cocoa was the discovery, in the years immediately preceding 1830, of a method for separating the fat of the cocoa bean, called cocoa butter, so as to produce a powder that could be readily mixed with milk or water. Previous to this, prepared cocoa was known only in the form of chocolate cake, and, as the cocoa bean contains nearly half its weight of cocoa butter, the beverage made from this was less generally palatable and easy to digest than cocoa as it is drunk at present. The new invention not only improved the cocoa, but made it cheaper; and this, together with the assistance afforded by better methods of transport, and the reduction of import duties, has led to a very rapidly enhanced consumption during the past half-century. The circumstance is sufficiently illustrated by the fact that, since about 1830, the consumption of raw cocoa in the United Kingdom has increased from 234 tons to nearly 65,000 tons in 1916.

II. General Account of the Varieties grown and the Method of Preparation of the Raw Product for the Market

Although about 20 species of *Theobroma* are known and several of these produce fruit containing "beans" similar in general character to those employed commercially, it

may be said that, for practical purposes, only three species need be recognised as constituting raw cocoa as exported. These are *Theobroma Cacao, T. pentagona* and *T. sphaerocarpa.* The first species is that in most common use, and has split up in cultivation into some well-marked varieties, which may be roughly divided for the present purpose into three groups known respectively as Forastero, Criollo and Calabacillo. The Criollo variety of *T. Cacao* together with *T. pentagona* are found to be less hardy than the Forastero variety of the former and the species *T. sphaerocarpa*, but are said to produce a better quality of bean.

According to Van Hall (*Cocoa,* 1914, Chap. V.), Criollo cocoa is grown only in Venezuela, Ceylon, Java, Samoa, Madagascar and Nicaragua, whilst Forastero is found with it in the countries mentioned and alone in Ecuador, San Thomé, Trinidad, the West Indies, Gold Coast, Surinam, etc. Hart (*Cacao,* 1911, Chap. I.), however, classed most of the cocoa grown in Trinidad as Criollo, under the name of Trinidad Criollo. *T. pentagona* is a native of Central America, and is grown on a commercial scale only in Nicaragua, Mexico and Guatemala. It gives satisfactory stocks for *T. Cacao,* and its affinities with this species cause it to be regarded by some as a variety of the same. *T. sphaerocarpa* is said to be common in cocoa plantations in San Thomé (Johnson, *Cocoa: its Cultivation and Preparation,* 1912, p. 7).

Cocoa is capable of being grown in tropical countries where the humidity and mean temperature are suitable and fairly constant throughout the year. Permanent plantations are made, and require a reasonable amount of additional shade to produce the best results. The cultivation of the plant is simple, the chief operations, apart from that of collecting the ripe fruits, being the pruning and preservation of the ground surface in a clean condition, to prevent the attacks of insect and fungoid pests, to which the tree is very susceptible. Manuring is employed on a practical scale in some of the older plantations, especially in the West Indies, and inorganic as well as organic fertilisers are employed there. Promising results have been obtained by the use of green manures, especially

those consisting of leguminous plants grown *in situ*, to be applied later as a mulch to the land. In large tracts of cocoa-growing countries, however, notably in the Gold Coast and Nigeria, practically no system of manuring is generally employed, although the respective Departments of Agriculture in those countries have demonstrated the increased value of the crop to be obtained from the application of manures.

Cocoa trees come into bearing in the third to the sixth year according to the climatic conditions of the country, as well as the variety of plant. The fruits are produced on the main trunk and principal branches only, and fruiting occurs usually at the same point year after year, forming a kind of bark cushion on which the flowers are borne on their short stalks. The flowers are invariably fertilised by insects, and the fruit matures from five to six months after the flower opens.

The fruits are collected when ripe and conveyed to the factory or place where they are to be treated. They are then cut open and the interior is turned out. The latter consists of a conglomerate mass of seeds or beans surrounded by a shiny pulp, which has to be removed before drying can be effected. The process employed for attaining this is called " sweating " or " fermenting," and constitutes one of the most important operations necessary to render the bean capable of being employed as food. The fermentation process has several functions, among which are the removal of the sweet shiny tissue, the setting up of a condition of heat and alteration of the chemical constituents of the bean itself and the loosening of the kernel within the bean shell.

Fermentation is set up after the mass of beans, with their adhering pulp, have been placed in baskets, barrels, or in heaps for several hours, and is continued for a week or even more, until the pulp is liquefied and drains away. In order to obtain an even fermentation, the whole mass has to be constantly turned over. When the fermentation is complete the beans should be in a sufficiently clean state for the drying process which follows. In some places the beans are washed before being dried, but no advantage seems to be obtained by this.

The beans may be entirely or partially dried in the sun; in the latter case the completion of the work is assisted by means of various kinds of mechanical apparatus designed for the purpose. The chief object of the whole preparation is to obtain beans in a good, firm and even condition, fermented and dried in such a manner that they give a good "break" and possess kernels having the requisite colour and mellow flavour found in the best quality of the product. Freedom from bitterness, unripe seeds and mildew are qualities sought after.

The dried beans may be shipped without further treatment or may be polished and clayed, as is frequently the case in the West Indies. The latter operation, which is indicated by its name, was probably introduced in the first instance to assist the drying by the absorption of the remaining coating of the gummy pulp which readily takes up atmospheric moisture and thereby induces the formation of mould; but latterly the addition of clay has been used to disguise the presence of blackened beans as well as to increase the weight of the produce. Polishing, which is termed "dancing" in the West Indies, is a means of developing a bright external appearance of the beans.

Much of the cocoa produced in the world is grown and prepared by natives alone, wholly unacquainted with the best methods of producing a marketable product. These people, moreover, are usually disinclined to exert themselves more than at present in the cultivation or preparation, unless they can be induced to do so by the receipt of a marked pecuniary advantage.

Cocoa is packed in sacks or barrels for shipment after having been graded by merchants in the producing countries.

This short account is only introduced as a preliminary to the discussion of the production and consumption of the product; for further particulars as to the cultivation and manufacture of cocoa reference should be made to standard works on the subject, such as—*Cocoa: Its Cultivation and Preparation*, by W. H. Johnson, F.L.S. (London: John Murray, 1912); *Cacao: A Manual on the Cultivation and Curing of Cacao*, by J. H. Hart, F.L.S. (London: Duckworth & Co., 1911); and *Cocoa*, by Dr. C. J. J. van Hall (London: Macmillan & Co., 1914).

III. The Production of Cocoa

The table opposite shows the production of raw cocoa in the chief producing countries in the years 1912 to 1917, as far as figures are available. The figures for British countries represent the exports as recorded in the official trade returns; in the case of foreign countries the statistics are compiled from various sources, most of those for the years 1915, 1916 and 1917 being obtained from Messrs. Theo. Vasmer & Co.'s report, published in *West Africa* (August 31, 1918, p. 511).

The figures show that the British Possessions have produced over 40 per cent. of the world's output of cocoa during the past three years, the Gold Coast alone producing more than one-quarter of the total. Trinidad, the second most important British country in regard to cocoa production, and the fifth on the list of the world's output, contributed one-twelfth, the West Indies as a whole being responsible for nearly one-eighth. Among the British West Indies, other than Trinidad, Grenada is the first as regards the output of cocoa, Jamaica producing about one-half to two-thirds as much as Grenada. Dominica grows nearly all the cocoa exported from the Leeward Islands; there is, in addition, only a very small output from Montserrat. In the Windward Islands, St. Lucia and St. Vincent have an output far less than that of Grenada. Nigeria (that is, the Southern Provinces) has made rapid progress in recent years, and now ranks next to Trinidad amongst British countries as a producer of cocoa. Ceylon produces less than Grenada, and, as a rule, more than Jamaica. The other British Possessions in the list, namely British Guiana, Uganda, British Honduras, Fiji, Mauritius and Seychelles, are at present of little or no importance as regards cocoa production.

Cocoa Production in Foreign Countries

Before referring in detail to the production of cocoa in the British Empire, some account may be supplied here of that with respect to the foreign countries in which the tree is cultivated.

In 1881 the production of Ecuador had reached 10,140

Production of Raw Cocoa

	1912.	1913.	1914.	1915.	1916.	1917.
	Cwts.	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
Gold Coast .	772,933	1,011,071	1,057,764	1,545,560	1,443,236	1,819,280
Trinidad .	370,764	429,610	566,499	482,870	479,393	626,294
Grenada .	101,043	105,284	102,690	120,402	109,772	
Jamaica .	65,675	46,359	72,299	68,487	64,360	
St. Lucia .	17,094	14,588	14,232	18,478	14,575	11,716
Dominica .	11,609	9,560	8,602	10,664	5,514	
St. Vincent .	2,005	1,908	2,010	2,114	1,596	1,191
Montserrat .	33	40	24	29	49	
Total, Brit. W. Indies	568,223	607,349	766,356	703,044	675,259	
Nigeria .	67,801	72,427	98,777	182,096	179,121	308,841
Ceylon .	71,754	68,526	54,633	83,483	73,245	72,697
British Guiana	102	505	445	533	416	71
Uganda .	—	—	—	164	258	
Brit. Honduras	93	445	184	164	164[1]	
Fiji . .	80	70	108	94	21	
Mauritius .	—	19	20	20	—	—
Seychelles .	14	15	4	3	—	—
Total, Brit. Empire	1,481,000	1,760,427	1,978,291	2,515,161	2,371,720	2,857,500[2]
Brazil . .	609,840	595,160	802,236	885,142	860,347	1,094,561
Ecuador .	708,374	774,723	829,025	728,461	839,606	800,000[2]
San Thomé .	660,571	657,651	655,853	588,271	652,797	607,753
San Domingo	410,069	383,264	408,335	397,960	414,293	478,000[2]
Venezuela .	281,245	291,402	352,127	359,724	298,760	394,437
Cameroons .	89,580	103,636	80,000[2]	[3]	[3]	[3]
Fernando Po	43,876	55,588	61,868	76,058	65,909	73,736
Dutch Guiana	19,006	30,077	37,252	33,611	39,632	37,921
Java . .	46,534	41,390	31,112	28,713	28,949	30,600
Haiti . .	61,306	34,992	41,837	35,067	36,622	30,364
Cuba . .	39,368	27,636	36,228	33,060	29,500[2]	29,500[2]
Belgian Congo	16,633	17,000	9,503	12,200	15,152	15,310
Guadeloupe .	18,196	17,878	22,126	[3]	[3]	[3]
Samoa . .	14,400	16,000	13,000[2]	[3]	[3]	[3]
Martinique .	9,860	10,305	8,835	[3]	[3]	[3]
Costa Rica .	6,081	7,559	6,496	[3]	[3]	[3]
Other Foreign Countries[4]	18,400[2]	19,500[2]	20,000[2]	166,000[2]	176,000[2]	179,000[2]
World's Total[5] .	4,534,000	4,844,000	5,394,000	5,857,000	5,829,000	6,628,000

[1] *Figure for* 1915. [2] *Estimates.*

[3] *Included in "Other Foreign Countries."*

[4] *Colombia, Mexico, Togoland, Gaboon, German New Guinea, Madagascar, French Guiana, German East Africa, Ivory Coast, Dahomey, Réunion and New Caledonia; and in* 1915–17, *also Cameroons, Guadeloupe, Samoa, Martinique and Costa Rica.* [5] *Approximate figures.*

tons, and by 1898 it had more than doubled, reaching 20,517 tons; the next year saw an increase to 26,187 tons, and in 1908 it was 31,214 tons. There was then a steady

increase to 38,649 tons in 1911, since when the output has continued to increase on the whole, the exports in 1916 reaching 41,980 tons. Cocoa is the export of by far the greatest value in Ecuador, amounting to about three-quarters of the total value of the exports in 1916.

Since 1899, when the output was 13,713 tons, the cocoa production of San Thomé has increased, with fluctuations, to 32,640 tons in 1916. By the end of 1903 it had reached 21,703 tons; there was a drop in the next year to 20,172 tons, but it increased in 1905 to 25,264 tons. It then remained steady until 1908, when the export became 28,109 tons, followed by 29,782 tons and 36,086 tons in 1909 and 1910 respectively.

Brazil in the year 1913 ranked fourth on the list of cocoa-producing countries, but according to statistics published in *West Africa* (1918, **2**, 511), the exports reached 54,728 tons in 1917, a quantity exceeded only by that from the Gold Coast. During the period 1902–12 the lowest export was 20,273 tons in the former of the years mentioned, and the highest 34,994 tons in 1911. On the whole there was a steady increase during the period. Cocoa was fourth in value among the exports in 1916; in that year its value was more than £2,500,000, the total exports being worth about £59,000,000. Most of the cocoa went to the United States, France and the United Kingdom in that year.

In 1890 the export of cocoa from San Domingo was only 1,378 tons; by the end of 1905 it had become 12,405 tons, and there was proportionately a great increase in the next few years to 18,705 tons in 1908. The year 1909 saw a quick decline to 14,584 tons, since when there has been a generally speedy increase to 20,715 tons in 1916. Among agricultural products exported from San Domingo, cocoa became the most important as regards value for the first time in 1913. In recent years the United States has displaced Germany as the chief market for San Domingo cocoa.

Venezuela, the seventh on the list in the order of cocoa production, had in the course of many years reached an output of 6,815 tons in 1894, and 11,712 tons in 1900. A sudden fall in 1901 to 7,736 tons was succeeded by a

rapid rise to 12,843 tons in 1904. The production remained at about the last-named figure until 1908, when it suddenly rose to 16,046 tons; since that year the output has fluctuated between 14,062 tons (in 1912) to 17,986 tons (in 1915). Most of the Venezuelan cocoa goes to France.

The relative importance of cocoa growing in some of the chief countries of production is indicated to some extent by the following figures showing the exports of cocoa in cwts. per square mile:

San Thomé	1,487·9
Grenada	785·7
Trinidad	230·5
San Domingo	21·2
Gold Coast [1]	12·6
Ecuador	6·6
Venezuela	0·8
Brazil	0·2

[1] *Colony and Dependencies.*

To the first three of these countries Fernando Po should be added as an island where cocoa plantations absorb a preponderating share of the land used for agricultural purposes. Care is to be taken in making use of the figures given above, as the nature of the country and the extent to which other crops receive attention prevent their being employed for making strict comparisons as to the degree to which cocoa growing may be extended or improved in the countries mentioned.

Cocoa Production in Individual British Colonies and Protectorates

The Gold Coast.—The production of cocoa in the Colony and Protectorate of the Gold Coast, which is exclusively a native industry, is noted for its phenomenal growth. The first shipment, of 80 lb. only, was made in 1891. By 1898 the production had reached 3,698 cwts., and thereafter it nearly doubled itself every year until 1902, when it had reached 47,923 cwts., valued at £94,944. After 1902 the next great increases were from 45,578 cwts. in 1903 to 102,245 cwts. in 1904; from 101,854 cwts. in 1905 to 179,505 cwts. in 1906; from 254,874 cwts. in

1908 to 404,264 cwts. in 1909, and from 452,616 cwts. in 1910 to 794,530 cwts. in 1911. In 1912, 772,933 cwts. were exported, valued at £1,642,733.

The exports of cocoa from the Gold Coast during the years 1913–17 were as follows:

	1913.	1914.	1915.	1916.	1917.
Total quantity *cwts.*	1,011,071	1,057,764	1,545,560	1,443,236	1,819,280
,, value .	£2,489,218	2,193,749	3,651,341	3,847,721	3,146,851
To	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
United Kingdom .	533,032	573,436	1,034,240	749,701	811,060
France . . .	168,811	231,552	421,020	505,436	419,760
United States of America . .	20	45	90,300	187,411	580,140
Holland . . .	—	—	45,137	—	—
Germany . .	309,208	207,594	—	—	—

The enormously preponderating interest taken in cocoa in the Gold Coast is indicated by the following table showing the value of the exports of the chief products in the years 1913–17:

	1913. £	1914. £	1915. £	1916. £	1917. £
Cocoa . . .	2,489,218	2,193,749	3,651,341	3,847,721	3,146,851
Kola nuts . .	144,705	142,180	139,163	130,565	239,134
Rubber . . .	87,915	21,631	25,167	78,865	110,272
Palm-kernels . .	159,128	88,671	50,512	85,899	74,911
Lumber . . .	366,094	240,878	90,661	93,980	69,128
Palm-oil . .	65,651	37,646	25,769	38,299	24,770
Gold . . .	1,626,003	1,659,435	1,755,552	1,200,868	1,718,483
Total value of all exports . .	5,427,106	4,942,656	5,943,631	5,816,527	6,364,925

The total production of cocoa in the Gold Coast has increased to an even greater extent than is shown in the export figures. According to the *Report on Trade and Customs Revenue*, 1917, owing to the shortage of shipping, preference had to be given in the exports to the United Kingdom to palm-kernels and palm-oil, and only a small proportion of the 1917–18 season's crop could be exported, whilst much of the 1916–17 season's crop also remained in the Colony.

The increased cocoa output in recent years has been due largely to extended production in Ashanti. The exports from this province increased from 2,960 cwts. in 1906 to 358,780 cwts. in 1915. In 1916 there was a still further increase in production, but owing to the low prices

ruling, due to shipping difficulties, a large part of the crop was not sold, some in fact not being picked, and the exports fell to 295,440 cwts. It is anticipated that when the market becomes normal again the output from Ashanti will continue to show a large increase. According to the *Annual Report of the Agricultural Department of the Gold Coast* for 1914, in that year there was actually a slight decrease in the shipments from the ports of the Eastern and Central Provinces—the original areas for cocoa production; the percentage distribution of production in the year mentioned was: Eastern Province, 57; Central Province, 20; Western Province, 23, of which more than 90 per cent. came from Ashanti.

Gold Coast cocoa, known in the markets as "Accra," from the chief port of shipment, is graded amongst the lowest qualities of the product in respect to price. The better sorts are, however, priced with Bahia from Brazil, which is usually reckoned somewhat better than San Thomé and San Domingo (Samaná) cocoa. The quality has very much improved, however, within the last few years, especially in the older producing districts, owing to the greater care that is being taken in its preparation. At present, the difference between the prices of the best and the worst grades of Gold Coast cocoa does not offer sufficient inducement to the producer to improve his quality or for the middlemen to exercise more care in grading, and, unless a comparatively better price is established for an improved class, there is the possibility of a complete reversion to the low standard of quality originally exported. Experiments have been conducted by the Department of Agriculture on methods of preparing cocoa, and the results of the examination and commercial valuation of specimens of the products sent to the Imperial Institute will be found in this BULLETIN (1907, **5**, 361; 1912, **10**, 240, 556).

The variety of cocoa in general cultivation is Amelonado. That called Cundeamor by the officials of the Department of Agriculture, owing to its outward resemblance to a Ceylon type of that name, has been grown experimentally and a sample of the beans examined at the Imperial Institute proved to be superior to the ordinary

fine fermented Accra cocoa (see this BULLETIN, 1912, **10**, 556). This variety is now being much sought after by the natives, and in time considerable areas should be planted with it.

Cocoa is grown experimentally at the Government Agricultural Stations at Aburi, Tarquah, Coomassie, Assuantsi, Kibbi and Peki, and has shown success at all these stations except at Tarquah. The distribution of cocoa seedlings and young plants in 1914 was 5,827, and of seeds over 29,000. Up to 1914 no artificial manures had been used in the experiments with the crop at the different stations, the object of the work being to investigate and demonstrate methods of cocoa growing best suited to the resources at the command of the natives. Much attention is given by the Agricultural Department to the control of cocoa pests. Agricultural instruction is carried out mainly by means of "renovated native farms," model farms and experimental stations, the personnel directly concerned with such instruction being travelling inspectors, travelling instructors, learners and local cocoa instructors.

Although in parts of the Gold Coast the rainfall may be considered somewhat low for the successful cultivation of cocoa, this is compensated for in most localities by the humidity which is ever present in the forest region wherein the plant is only grown. There are tracts of country indeed, such as that running along the sea-coast from Accra to Adda, where the conditions are quite unsuitable owing to the lack of rain, as also is the grass-land zone to the north of the central forested zone; but no attempt is likely to be made to plant cocoa in these regions, and it is the forested zone alone that must be looked upon as the cocoa area. Sufficient evidence of the suitability of this area for raising cocoa is shown by the remarkable rapidity with which the output has increased, the development of which has been encouraged by the evidence of rapid maturity and productivity given by the plant in such situations. The extension of cocoa growing has taken place at the expense of the native palm product industry; and at the present time there is some anxiety as to the future of agriculture in the Gold Coast through

the fact that no reserve exists in the form of a crop that could make up for any important failure of cocoa. Most of the farms are small, but there is a tendency to increase their area, and there are grave fears that farms are being extended beyond the limits which the farmers are capable of maintaining in a satisfactory condition, while a further cause for anxiety is the fact that the natives do not pay sufficient attention to the combating of the pests and diseases that are so likely to increase to a damaging degree in the case of any widely grown agricultural product.

The most important of these are three insects : *Sahlbergella singularis, S. theobroma* and a *Helopeltis* sp. (allied to *H. schoutedeni* from the Congo). The two last mentioned were described and figured by Dudgeon (*Bulletin of Entomological Research*, 1910–11, **1**, 59). The two species of *Sahlbergella* puncture the trunks and stems of the trees and by sapping the juices destroy the vitality of the whole tree. They are apparently only found in regions where the plantations are not kept sufficiently clean, and can be destroyed by clearing away the undergrowth in the plantations and spraying the trunks and branches with kerosine emulsion. The Helopeltis attacks the unripe fruits and causes small round black spots to appear on the surface, each of which represents a puncture. These punctures in themselves often cause a deformity in the shape of the fruit, but are also liable to permit the entry of destructive fungus spores, the result of which is the complete loss of the fruit. Other common pests in the Gold Coast are the larvæ of two boring beetles, *Aimatosterua buquetiana* and a *Glenea* sp., and a fungoid thread blight which appears to be common on many trees in the damper parts of Ashanti. For further details as to the cocoa industry in the Gold Coast, reference may be made to Johnson's *Cocoa: Its Cultivation and Preparation* (London: John Murray, 1911), and to the Note on the Trade and Agriculture of the Gold Coast on p. 95 of this Bulletin.

Nigeria. — Cocoa cultivation is carried on in the Southern Provinces of the Protectorate and in Lagos Colony, and, as in the case of the Gold Coast, the production of cocoa in any quantity is a matter of recent date. In 1898 the exports only amounted to 687 cwts.,

value £1,579; they rose steadily to 3,442 cwts., worth £7,530, in 1902, and after a decrease in the next year there was a largely increased production, maintained steadily (except in 1905), and reaching in 1911 88,025 cwts., of value £164,664. In 1912 there was a decreased export amounting to 67,801 cwts., worth £130,542.

The exports of cocoa from Nigeria during the years 1913–17 are shown in the following table:

	1913.	1914.	1915.	1916.	1917.
Total quantity *cwts.*	72,428	98,777	182,096	179,121	308,841
,, value . .	£157,480	171,750	313,946	393,101	499,004
To	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
United Kingdom .	39,731	75,153	153,912	109,652	73,840
France . . .	—	—	8,539	18,723	18,959
United States . .	—	—	19,632	50,746	216,042
Germany . .	32,697	23,624	—	—	—

In 1917 the value of the cocoa exported was only exceeded, among agricultural products, by that of oil-palm products and of ground nuts, as is shown in the following table, which gives the value of the exports of the chief products shipped from Nigeria in 1913–17:

	1913. £	1914. £	1915. £	1916. £	1917. £
Palm-kernels . .	3,109,820	2,541,150	1,692,711	1,739,706	2,581,702
Palm-oil . . .	1,854,384	1,571,691	1,462,162	1,402,799	1,882,997
Ground nuts . .	174,716	179,219	72,177	473,653	710,308
Cocoa . . .	157,480	171,750	313,946	393,101	499,004
Cotton . . .	159,199	150,791	56,351	243,949	234,338
Hides and skins .	197,213	505,786	302,420	538,917	198,332
Rubber . . .	89,993	38,854	38,113	39,192	32,350
Timber . . .	106,155	86,522	54,556	49,361	21,282
Tin ore . . .	567,959	7c6,988	723,480	859,603	1,485,887
Total value of all exports of local produce . .	6,815,982	6,150,704	4,873,762	5,883,593	8,482,325

Most of the cocoa exported from Nigeria, known in the European markets as Ibadan cocoa, is of a low grade and inferior to ordinary Gold Coast cocoa. That better cocoa can be produced by more careful cultivation and preparation is shown by the fact that the crops produced on the better managed farms in the Agege district realise prices equal to those obtained for the best Gold Coast cocoa. The variety usually grown is Amelonado.

The Department of Agriculture of the Southern Provinces is conducting experiments with a view to improving the quality of the cocoa, and samples of the products have been examined at the Imperial Institute (see this BULLETIN, 1914, **12**, 213; 1915, **13**, 553). Much success has been attained through the use of artificial driers which, it is suggested, should be employed in the rainy season. The Department maintains experiment stations at Ibadan, Calabar, Onitsha and Agege, and at all of these cocoa is grown. An entomologist and a mycologist are attached to the Department for the study of pests and diseases.

Plantations at Agege were found attacked by a fungoid disease of the stem which caused the death of branches and seriously affected the productiveness of the tree. The bark sapper *Sahlbergella singularis* has been found in the Southern Provinces effecting the same damage as that with which it is accredited in the Gold Coast and the Congo. A leaf-eating beetle, *Adoretus hirtellus*, is found attacking trees in some districts and two species of scale have been observed. The latter are fortunately controlled by predatory lepidopterous larvæ.

Agricultural instruction is carried on chiefly through the medium of practical demonstrations on farms, and by means of model plots and the experiment stations, as well as by the teaching of agricultural pupils and the holding of agricultural classes in schools with the aid of school gardens; native instructors are trained to assist in this work. The efforts towards instruction are also aided by the holding of agricultural shows and a cocoa competition. Leaflets and bulletins dealing with agricultural subjects are issued by the Department.

Cocoa fermenting demonstrations are given by Instructors of the Department in the principal cocoa-growing districts, and in 1916 a bonus was paid by merchants for all cocoa prepared in the manner demonstrated in order to encourage the natives to produce properly prepared beans. At present Ibadan is the largest producing centre, with a smaller output in the Calabar and Abeokuta Provinces and the Agege district, and, as a result of the Department's efforts to encourage cocoa cultivation in Benin,

it is anticipated that in a few years this Province will be an important producing centre.

A great deal of new land has been planted with cocoa within the last four or five years, and a very large number of plants have been supplied by the Department of Agriculture, no fewer than 62,000 being distributed in 1914 alone. When the newly planted areas come into bearing and as planters become better acquainted with the proper way to cultivate the crop, it is anticipated that a very considerable increase in the exports will be shown.

Sierra Leone.—Although cocoa is known to have been grown in this Colony as early as the end of the sixteenth century, it is not yet of any economic importance. The Agricultural Department possesses, however, several plantations on Government farms, and the crop is grown on the lands of chiefs with its assistance.

In the *Annual Report of the Agricultural Department* for 1913 it is stated that cocoa seems to grow best in the Sherbro country, where the original plantings appear to have been made. The opinion is also given that successful ventures may be made with the crop in the "pockets of soil" which are to be found in the valleys near Freetown and in the peninsula.

The preponderating interest, however, in the exploitation of oil-palm products and kola render any great extension of the industry improbable, even if the natural conditions themselves were found to admit it.

On the whole, Sierra Leone must be regarded as less suited for cocoa plantation than the countries lying to the south of it. The climatic conditions are for the most part unfavourable, excessively heavy rainfall for half the year alternating with a continuous dry period for the other half is found in most localities—conditions which are prejudicial to the proper growth of the tree. It is for this reason, also, that it is extremely unlikely that cocoa will ever become an important export from Sierra Leone.

Uganda.—Small shipments of cocoa are now being made regularly from Uganda, the exports in 1915–16, when the product was first shown separately in the Trade Returns, amounting to 164 cwts., valued at £405, and in

the following year to 258 cwts., valued at £562. Most of the cocoa is grown on European plantations, and in 1916–17 there were 248 acres planted with trees over five years old in the Mengo and Entebbe districts of Buganda Province. The cultivation of the crop is extending among European planters, and in the same year 2,510 acres were occupied with plants under five years old in the Buganda Province, and about 750 acres in various districts in the Northern, Eastern and Western Provinces, whilst 16,980 cocoa seeds were distributed to growers from the Kampala Experiment Station. The area of cocoa cultivated by natives in 1916–17 amounted to 548 acres, all in the Northern Province, and there were also 137 acres under the crop at Misson Stations in the Buganda and Eastern Provinces.

Experimental and model plots of Forastero (including Calabacillo) cocoa at Kampala are showing success; but this is not the case so far at Kakumiro, where the plant is also being tried, probably because of a severe dry season and the altitude of the station. It is stated by the Government Botanist that the enemies of cocoa occur and cause loss only to a very small degree, so far; but the warning is given as to the likelihood of the increase of their occurrence with the extension of the cultivation. The only diseases reported so far are die-back, pod disease and root disease; and the Entomologist recorded as insect pests: green fly (*Toxoptera*), the Adoretus beetle, cocoa fruit fly (*Ceratites*), scale insects and mole crickets, whilst the more serious pest known as mosquito blight (*Helopeltis*) has appeared on one estate and is receiving study. The work of the Agricultural Department is naturally concerned mainly with the chief plant products of the country, namely cotton and coffee; and veterinary matters receive much attention. There are three experiment plantations, including the two mentioned above; and a large staff of native agricultural instructors is kept.

In regard to the present prospects of cocoa growing in Uganda, the *Annual Report of the Department of Agriculture* for 1914–15 states: " Sample shipments have been well reported upon, and the crop, when planted under

suitable conditions, encourages planters to extend steadily their cocoa area." There is no doubt that conditions in Uganda offer an opportunity for a large extension of cocoa production, provided that care and good cultivation are exercised and carried out thoroughly in order that the present comparative freedom from pests and diseases may be maintained.

East Africa Protectorate.—The cultivation of cocoa in this country is in a more undeveloped state than in Uganda. Some experimentation with the crop is being conducted by the Department of Agriculture, which apparently intends to increase the scope of the trials with cocoa seed imported from the last-named country. So far, however, the experiments conducted at the Mazeras Farm and at Kibos have not been successful. The chief attention of this Department is given at present to the principal plant products of the Protectorate, viz. sim-sim (sesame), maize, cotton and other fibres, and copra, and to the veterinary work concerned with its valuable animal products. Much of the direct agricultural education is carried out by means of plant instructors. There is a Diseases of Plants Prevention Ordinance whose working is assisted by the Entomologist and a Plant Import Inspector.

Although there is little information as to the prospects of cocoa growing, and the success with coffee in this country cannot be taken as a criterion of similar success with cocoa, as the coffee is chiefly grown in the highlands of the Protectorate, nevertheless, in the very divergent natural conditions which the country affords, there is room for a cocoa industry that should attain to some importance in the agricultural economy of British East Africa.

Nyasaland.—No attention to cocoa cultivation or experimentation is given in this Protectorate, where the chief crops are cotton, tobacco and tea. These, together with maize and other minor crops, receive the chief attention of the Agricultural Department, in addition to the important part of its work that is concerned with veterinary matters. This Department is also responsible for a forestry division and an entomological division, and assists in the

carrying out of the provision of a Plants Protection Ordinance.

The circumstance that Nyasaland lies at a distance of as much as ten degrees south of the Equator, and extends southwards for a further seven degrees, combined with the existence of the more rigorous changes of the weather consequent on the possession of a continental climate, would restrict in any case the area that may be found fitted for cocoa growing. But the chief limiting factor is found in the general elevation of the country, which places the greater part of it above the altitudes for successful cocoa cultivation. Conditions are only likely to be found favourable in this respect along the depression of the river Shiré; and even here it is most probable that the plant would suffer severely from lack of rainfall.

Trinidad and Tobago.—Although the production of cocoa in this Colony has been exceeded in recent years by that of the Colony and Protectorate of the Gold Coast, it still has an important share in the supply of cocoa from British Possessions to the United Kingdom, while the industry is of great local importance. By 1840 the export of cocoa had reached about 1,000 tons, and it increased with fluctuations, but in a generally steady manner, to an output of more than 26,000 tons in 1910.

The exports of cocoa from Trinidad during the years 1913–16 were as follows:

		1913.	1914.	1915.	1916.
Total quantity	*cwts.*	429,610	566,499	482,870	479,593
,, value		£1,403,397	1,469,893	1,865,266	1,637,268
To		*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
United Kingdom		35,052	65,269	98,553	90,383
Canada		6,160	6,333	10,261	10,000
United States		211,451	279,502	299,757	255,928
France		139,446	166,047	72,398	114,980
Holland		16,504	17,740	—	—
Germany		9,475	15,128	—	—
Other countries		11,522	16,480	1,901	8,102

In 1917 the record quantity of 626,294 cwts. was exported from Trinidad.

It will be seen that the greater part of the cocoa produced in Trinidad goes to the United States of America

and to France, although the exports to the United Kingdom have been increasing on the whole in recent years.

The importance of cocoa to the Colony is indicated in the following table showing the value of the exports of the chief agricultural products in 1913–16 together with the value of the total exports (excluding bullion and specie) in each year:

	1913.	1914.	1915.	1916.
	£	£	£	£
Cocoa	1,403,397	1,469,893	1,865,266	1,637,268
Sugar and sugar products	432,967	613,082	1,163,166	1,458,802
Coconuts and products .	96,914	86,680	96,811	142,788
Value of total exports of local produce . .	2,344,366	2,484,576	3,422,270	3,293,670

The soil and climate of Trinidad are particularly suited to the growth of cocoa, the most favourable localities being the numerous valleys which extend into the mountain ranges in the northern and eastern parts of the island. According to the official returns, the area under cocoa in Trinidad and Tobago in 1914–15 was 336,154 acres, out of a total cultivated area of 470,887 acres; the area of the Colony is 1,263,697 acres, and large tracts of excellent cocoa land still remain unalienated from the Crown and available for purchase by settlers.

Trinidad cocoa is of very uniform quality and realises excellent prices. It was stated a few years back that the cocoa had deteriorated in quality, but a Commission which was appointed in 1914 to enquire into the allegations reported that the most that can be said is that a change has taken place in the relative value of Trinidad cocoa as compared with that of some other cocoas owing to the greater care now taken in the preparation of the latter. Trinidad cocoa is usually clayed, and complaints have been made in regard to it on this score; but the general opinion seems to be that the practice has much to recommend it if not carried to excess.

Experiments on a large scale have been commenced in recent years by the Department of Agriculture with a view to increasing the production by improvements in the methods of cultivation. These experiments are carried out chiefly at the River and St. Augustine Estates; experiments are also conducted on private estates. The number

of cocoa plants distributed by the Agricultural Department from the St. Clair Experiment Station in the year 1916 was 15,497; and it is of interest to note that this quantity included 735 budded cocoa plants. The Government is endeavouring to improve the methods of cultivation, especially among the small peasant proprietors, of whom there is a very large number, by means of cocoa prize competitions, agricultural education in elementary and secondary schools, school shows, home reading courses and the training of pupils by the Agricultural Department, while two agricultural instructors are solely occupied in visiting peasant proprietors. General instruction in agricultural matters is assisted by the Trinidad Agricultural Society, and both this Society and the Agricultural Department issue periodical agricultural journals.

In Tobago a steadily increasing output of cocoa reached 11,534 cwts., worth £32,295, in 1913; in 1914 the exports were 11,016 cwts., worth £30,844, and in 1915 they were worth £42,755, and in 1916 14,593 cwts., valued at £47,672. Coconut products are second to cocoa among the chief exports of this island, the value of the exports being £10,659 in 1914, £13,150 in 1915, and £11,439 in 1916. Cotton growing has received special attention in Tobago in recent years, but no success has resulted so far. Since the war began the efforts of the Agricultural Department have brought about a largely increased output of vegetables (ground provisions) on the part of small-holders in this island, and the exports of these products in 1916 amounted to 14,678 cwts., valued at £10,458. Tobago possesses a Botanic Station from which 8,976 cocoa plants were distributed in 1916.

Jamaica.—The cocoa production of this island is somewhat less than that of Ceylon. The industry is, however, much older in Jamaica, where cocoa was being grown at the time of the conquest of the island by the Spaniards, in the middle of the fifteenth century. As in Trinidad and Martinique, the history of cocoa growing in Jamaica contains the record of a "blast" (in 1727), which destroyed the trees and necessitated the recommencement of the industry in these as well as other West Indian islands; the phenomenon was most probably in the

nature of a hurricane or series of hurricanes, although it is considered by some to have been an outbreak of disease. The reintroduction of cocoa growing did not take place in Jamaica by any means as early as in Trinidad, and by the middle of the seventies there was only a small export of about twenty tons. From this time there was an increase in the output, which had reached 21,002 cwts., with a value of £53,380 in 1889; by 1906 it was 31,066 cwts., worth £52,813, although in 1902 the export had reached as much as 39,953 cwts. The years 1907 to 1912 saw alternations between 47,564 cwts. in the former and 65,675 cwts. in the latter, with low yields in 1908 and 1910.

The exports of cocoa from Jamaica during the years 1913–16 are shown in the following table:

	1913.	1914.	1915.	1916.
Total quantity . *cwts.*	46,359	72,299	68,487	64,360
,, value . . .	£114,738	153,033	204,321	167,337
To	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
United Kingdom . .	24,227	31,442	30,373	37,352
Canada . . .	2,728	4,083	5,213	5,561
United States . .	6,386	11,741	32,247	20,713
France . . .	9,900	19,276	—	—
Germany . . .	1,886	4,654	—	—
Other countries . .	1,232	1,103	654	734

The value of the exports of the chief agricultural exports in 1913–16 is shown in the following table:

	1913. £	1914. £	1915. £	1916. £
Logwood and logwood extract . . .	276,851	288,617	391,241	800,284
Sugar . . .	52,172	196,345	256,190	503,054
Rum . . .	101,328	102,063	185,456	352,091
Bananas . . .	988,236	1,490,563	599,529	222,496
Coconuts . . .	135,486	123,049	102,486	179,392
Cocoa . . .	114,738	153,033	204,321	167,337
Coffee	158,578	166,140	129,104	145,110
Total value of all exports of local produce .	2,216,212	2,800,576	2,202,615	2,769,379

Jamaica cocoa is largely of the finer kind, being somewhat similar but inferior to Trinidad cocoa, though the quality of the whole export varies more than that of the shipments from the latter island.

Official returns give an area of 12,131 acres under

cocoa in Jamaica in 1916. The amount of cocoa grown has increased in recent years, partly through the abandonment of banana cultivation by some owners, on account of the severe damage and loss caused to that crop by hurricanes. Cocoa has often been planted with success in exhausted banana cultivations, the banana being used as temporary shade.

One of the means of encouragement of cocoa growing among small-holders in this island has been the distribution of cocoa plants, and some indication of the progress that has been made is supplied by the fact that the number of cocoa plants sent out to the small-holders in the season 1914–15 was nearly double that distributed in 1912–13, viz. nearly 145,000 as against more than 72,500. In later years the number has fallen off, about 65,500 plants being distributed in 1917–18. The Agricultural Department has charge of extensive gardens and nurseries, where the work is chiefly concerned with the propagation and distribution of plants, and at several of them cocoa is grown. Experiments on a large scale are mainly carried out at two experiment stations. Work at the Government Laboratory includes investigations in connection with the agricultural products of the island; and the services of a microbiologist and an entomologist are available for enquiry into pests and diseases, as well as for other matters connected with agricultural production. For the control of pests and diseases a Diseases of Plants Law is in force.

For higher agricultural education there is a Government Farm School. In connection with the more general work agricultural instructors are provided, and attention is given to agricultural subjects in a practical manner in the elementary schools. Instruction in agriculture is widely assisted by the Jamaica Agricultural Society, with its branch societies. Both the Agricultural Department and this Society publish periodical journals dealing with their work.

As has been pointed out, plantation cocoa is raised in Jamaica side by side with the product of small-holders. That there is a promising outlook for cocoa in the island is indicated by the larger attention that is being given to

sanitation in the old plantations, whilst the *Annual Report of the Department of Agriculture* for 1914–15 states: "There is every reason to place the highest confidence in the soundness of cacao as one of our leading staples."

The Windward Islands.—Of the islands in this group, Grenada easily occupies the first position as a producer of cocoa; its output is five or six times as great as that of St. Lucia and St. Vincent taken together. Notwithstanding its small size, this island is reckoned among the chief cocoa-producing countries. In 1900 the exports had reached 94,369 cwts., and since then there has been a steady production ranging between 92,506 cwts. in 1903 and 120,402 cwts. in 1915, except in 1906, when it fell to 73,745 cwts.

The exports of cocoa from Grenada during 1913–16 are shown in the following table:

	1913.	1914.	1915.	1916.
Total quantity . *cwts.*	105,284	102,690	120,402	109,772
,, value . .	£303,074	280,308	402,395	449,944
To	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
United Kingdom . .	59,683	67,813	77,950	not available
France	15,806	7,499	—	
United States . .	29,712	27,130	41,619	
Other countries . .	83	248	833	

That the cocoa industry is by far the most important in the island is indicated by the following figures showing the values of the chief products exported during 1913–16 and the total value of all exports:

	1913.	1914.	1915.	1916.
	£	£	£	£
Cocoa	303,074	280,308	402,395	449,944
Nutmegs	25,205	21,165	25,320	31,947
Mace	18,939	15,655	16,999	16,873
Cotton	10,500	8,805	8,490	14,543
Total value of all exports	367,149	333,374	465,011	534,234

The production of the large quantity of cocoa in this small island means that a preponderating area is devoted to the crop; and it holds second place to San Thomé in the ratio of the export (in cwts.) to the whole area (in square miles), the figure being 785·7 as against 1487·8 for San Thomé. There is still room, however, for the exten-

sion of the industry, both as a plantation and a peasant crop; and with more careful cultivation, notably on the small holdings, a notable increase should be effected in the already large proportionate output. Grenada cocoa possesses a somewhat bitter taste, and fetches a price a little lower than that of Trinidad cocoa.

In St. Lucia the export of cocoa had by 1900 reached more than 10,000 cwts., and it has always exceeded this quantity since, except in 1901, when it was only 5,886 cwts. In the period 1900–17 the greatest production was 19,384 cwts. in 1909.

The exports of cocoa from St. Lucia during the years 1913–17 are shown in the following table:

		1913.	1914.	1915.	1916.	1917.
Total quantity .	*cwts.*	14,588	14,232	18,478	14,575	11,716
,, value .		£36,889	38,846	51,495	40,620	35,687
To		*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
United Kingdom .		6,002	9,400	14,930	not available	not available
France . . .		6,602	3,841	490		
United States . .		917	843	2,985		
Holland . . .		733	—	—		
Other countries .		334	148	71		

The position of the cocoa industry in St. Lucia is shown by the following figures of the values of the chief exports in 1916 and 1917: Sugar and products, £95,878 and £78,651; cocoa, £40,620 and £35,687; lime products, £6,360 and £6,945.

St. Lucia cocoa is usually quoted on the London market at a little below the price of Grenada fine.

The area of cocoa in the island in 1913 was officially estimated at 6,050 acres, but there has been little increase in its cultivation in recent years, chiefly because most of the planters in the island are giving increasing attention to the growing of limes and coconuts. The conditions admit, however, of a considerable increase of the area under cocoa.

St. Vincent possesses a small cocoa industry which produces about 100 tons. That it has made little progress in recent years is shown by the fact that while in 1898 the output had reached 1,668 cwts., in the next year it had fallen to 39 cwts.; but after that time it increased steadily, with a small fall in 1902 and in 1910, to 2,552

cwts. in 1911. In 1916 it had fallen to 1,596 cwts., valued at £5,214, as compared with £15,260 for cotton and £37,619 for arrowroot. As has been indicated already, there are other crops more suited to the natural conditions in St. Vincent, and these have proved more profitable for cultivation than cocoa.

The three islands, Grenada, St. Lucia and St. Vincent possess Agricultural Departments that work in association with the Imperial Department of Agriculture for the West Indies. In Grenada the Botanic Gardens distributed 3,325 cocoa plants in the season 1913–14, but since then the number has fallen off, 280 plants being distributed in 1916–17, and more attention is now being given by the Department to the raising of lime plants, of which 27,103 were distributed in 1916–17. Manurial experiments are carried out by the owners of three cocoa estates, with the assistance of the Agricultural Department. The growing of cocoa by peasants is encouraged by means of prize-holdings competitions in Grenada, and its cultivation forms a feature of the work in some of the Land Settlements in the island. In St. Lucia there is a distribution of about a thousand cocoa plants from the Botanic Station in each year; they are given free to the purchasers of Crown Lands, for the encouragement of cocoa growing by these peasants; cocoa does not, however, appear as a crop grown under the Land Settlement Scheme of St. Lucia. The distribution of cocoa plants from the Botanic Station at St. Vincent in 1913–14 was 2,400, but only 40 in 1916–17; cocoa does not form the subject of experimentation or of competition among peasant growers in this Colony. It should be stated that in the Windward Islands, and in the Leeward Islands mentioned below, there are schemes for the training of pupils and of cadets in agricultural subjects, and for elementary and secondary agricultural education; whilst courses of reading and examinations for those having the direction of work on estates are conducted by the Imperial Department of Agriculture for the West Indies.

Leeward Islands.—Cocoa is exported from Dominica and Montserrat, but the production of the latter island is very small, being only about two tons, worth approxi-

mately £100. In Dominica there was a steady annual production of approximately 10,000 cwts. between 1898 and 1912, except in 1899, 1901 and 1903. In 1913 and 1914 the exports decreased to 9,560 cwts. and 8,874 cwts. respectively, rising to 10,664 cwts. in 1915, with a fall in 1916 to 5,514 cwts.

The cocoa from Dominica receives a lower quotation on the market than Grenada cocoa. Although the area of Dominica is more than twice that of Grenada, the output of cocoa from the latter island is more than twelve times as great. The extent of the larger interest that is being taken in limes is indicated to some degree by the circumstance that in 1915–16 61,590 lime plants were distributed from the Botanic Station, as compared with 2,007 cocoa plants; it is emphasised by the fact that the exports of lime products in 1916 were worth £172,352 against the sum of £16,568 for cocoa. Nevertheless, the importance of cocoa as a crop for Dominica is recognised in the sustained attention that is being given by the Agricultural Department, with the advisory assistance of the Imperial Department of Agriculture, to experimentation in the manuring of cocoa and the vegetative propagation of the plant.

Cocoa contributed largely to the saving of agriculture in Dominica by the extension of its cultivation during the time of depression that followed the collapse of the sugar industry in the island. In recent years the cocoa plantations have suffered severely from hurricanes, and the Agricultural Department considers that the trees lost will not be replaced (*Annual Report for* 1917–18). It is stated that little attention is now being given to the crop, and no new plantings of any extent are being made; it is thought that ultimately cocoa growing in the island is likely to fall to the level of a minor industry.

British Guiana.—At the present time only about 2,000 acres are planted with cocoa in British Guiana and the produce is mainly used locally, the exports amounting to only about 400-500 cwts. annually. The very small importance of cocoa in the economy of the Colony is shown by the fact that in 1916 its export of 416 cwts. was worth only £1,261 in a total value of £3,362,523. The largest

export recorded was 25,530 cwts., valued at £55,448, in 1902. The small quantity that is exported brings a good price owing to the great care that is taken in fermenting and curing the beans. The variety cultivated is Forastero.

Experiments regarding shading and manuring have been carried out for some years by the Agricultural Department at the Onderneeming Government Farm, where there are nearly twelve acres of land under cocoa. The control of these experiments and the distribution of plants from the Botanic Gardens in Georgetown (amounting to more than 21,000 in 1916) together with the work of the Economic Biologist against insect pests and of the Mycologist against fungoid diseases, chiefly witch broom, constitute the chief efforts of the Agricultural Department with regard to cocoa; although a large amount of interesting investigation concerning the plant has been carried out at the Government Laboratory. Regarding agricultural instruction generally most of the teaching in classes is carried out by the Education Department, and at Queen's College; whilst the Agricultural Department gives practical agricultural instruction. Assistance in these matters is provided by means of school gardens, agricultural apprentices, agricultural industries and district agricultural shows. There is a Planters' Association in the Colony. The Agricultural Department works in conjunction with a Board of Agriculture and a journal is issued periodically by the latter body. A Plant Diseases and Pests (Prevention) Ordinance is in force in the Colony.

Under existing conditions increased cocoa growing in British Guiana is a matter for the small farmer alone, though the present position with regard to the industry is summed up in the *Annual Report of the Department of Science and Agriculture* for 1914–15, which states: "In some parts of the Colony cacao-planting is an industry of some promise, but it requires for its successful installation more capital than small farmers usually possess." Professor J. B. Harrison and Mr. C. K. Bancroft, in an article on "The Field and Forest Resources of British Guiana," published in this BULLETIN (1915, **13**, 225), state that there are plenty of openings for the development of cocoa planting in the Colony, the best land being that bordering

both banks of the Berbice River from about 30 to 150 miles from its mouth. As has been indicated, any large extension, especially as plantation cultivation, would need different conditions regarding labour and the provision of transport.

British Honduras.—There is only a small production of cocoa in this Colony, the output reaching 415 cwts., value £1,858, in 1907, and falling, with fluctuations, to 93 cwts., worth £413, in 1912, when the total value of all exports was £587,096. In 1913 the output increased to 349 cwts., and in the next two years there was a fall to 184 cwts. and 164 cwts. respectively. The position of cocoa in the Colony is shown by the values for the chief agricultural exports in 1914 given in the following table :

	Total exports.	Produce of Colony exported.
	£	£
Sapodilla gum (chicle)	234,483	80,120
Mahogany	196,182	74,609
Bananas	35,243	35,243
Coconuts	34,022	34,022
Cocoa	591	591

Trials conducted at the Botanic Station have shown that cocoa grows well under existing conditions, the variety Forastero showing, as may be expected, the best growth. There is also some demand for both cocoa and other plants, 3,650 cocoa plants being distributed in 1915. But the prospects of a large industry in plantation cocoa are at present very remote, both from the preponderating interest in the exploitation of the wild products of the Colony, and from the dearness of labour.

Ceylon.—Notwithstanding the fact that cocoa was introduced into Ceylon at the beginning of the nineteenth century, it was not cultivated as a main crop until after the decline of the coffee industry—brought about chiefly through the ravages of the coffee-leaf disease (*Hemileia vastatrix*)—when planters were endeavouring to find another crop for their plantations. In 1875 an export of about half a ton of cocoa was made, and by 1895 shipments amounted to 1,500 tons.

Between 1898 and 1901 the export fluctuated between 38,099 cwts., of value £110,884 and 47,471 cwts., worth

£154,755. Between 1902, when it was 61,476 cwts., and 1912, in which year it was 71,754 cwts., the lowest export was 55,621 cwts. in 1906, and the highest 93,851 cwts. in 1907.

The exports in the years 1913–17 are shown in the following table :

	1913.	1914.	1915.	1916.	1917.
Total quantity . . *cwts.*	68,526	54,633	83,483	73,245	72,697
,, value . . £	201,147	137,529	208,596	188,337	120,386
To	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
United Kingdom .	43,921	33,723	62,303	44,149	21,583
Canada . . .	1,143	—	1,146	620	2,231
New Zealand . .	1,430	1,719	3,241	3,109	1,757
France . . .	1,520	100	1,650	2,828	216
United States of America . .	3,634	5,507	4,827	1,460	7,397
Philippine Islands .	8,125	8,703	8,149	14,297	25,502
Other countries .	8,753	4,881	2,167	6,782	14,011

Although such a large proportion of the cocoa has come to the United Kingdom, most of it is, as a rule, re-exported (see table on p. 88).

The relative position of the cocoa industry in Ceylon is indicated by the following figures showing the value of the exports of the chief agricultural products in the last five years :

	1913.	1914.	1915.	1916.	1917.
	£	£	£	£	£
Rubber . . .	4,452,408	4,117,488	5,560,793	7,442,487	9,153,145
Tea	5,852,565	5,981,735	8,163,855	7,017,764	6,377,565
Copra . . .	1,397,284	1,549,861	1,117,123	1,457,897	881,033
Coconut oil .	1,115,847	892,821	863,935	595,643	672,044
Desiccated coconut	524,448	522,577	576,458	580,361	624,066
Areca nuts . .	202,609	119,896	223,047	186,768	196,933
Cocoa . . .	201,147	137,529	208,596	188,337	120,386
Cinnamon . .	160,908	107,778	133,179	83,712	64,517
Total value of all exports of local produce . .	14,949,084	14,047,427	17,715,551	18,989,198	19,508,333

The quality of Ceylon cocoa varies much : from the well-prepared plantation cocoa, which is classed among the finer kinds, to an inferior sort which is produced in considerable quantities. Like Java cocoa, that from Ceylon is a washed cocoa, and it resembles the former kind in its general characteristics.

The area under cocoa in Ceylon amounted to 44,280 acres in 1917. The chief areas are in the Kandy and Matale

districts; less important districts, each with about 1,000–2,000 acres under cocoa, are Kurenegala, Badulla and Kegalla. The configuration of the island and the consequently quickly-varying climatic conditions make the proportion of its area suited for the growing of cocoa comparatively small. The kind mostly grown is a Criollo, called locally O W Red Ceylon. Attempts have been made to grow Forastero kinds in the place of this, but the older variety has maintained its position as the chief cultivation. Interplanting of cocoa with Para rubber—the Para rubber supplying some shade and an additional source of profit—has been receiving increasing attention in Ceylon.

Cocoa has been made the subject of much study by the Agricultural Department in Ceylon, particularly in regard to the question of interplanting, the provision of shade and the control of pests and diseases; for the latter the services of an entomologist and mycologist are available. Manurial experiments with cocoa, and other agricultural work are carried out at the Peradeniya Experiment Station; similar work is conducted at six additional centres by means of gardens and experiment stations, and the services of a Government Chemist are provided for agricultural investigation. The work of these institutions is published chiefly in the *Annals of the Royal Botanic Gardens, Peradeniya*, and in the *Bulletins of the Department of Agriculture.* Much attention is given to advisory assistance on estates and to native agricultural instruction, and the latter is assisted by teaching in elementary schools aided by work in school gardens. For secondary agricultural teaching a comprehensive system of instruction has been inaugurated by the Agricultural Department. These efforts are carried out with the support of an active Agricultural Society, which issues a periodical journal, the *Tropical Agriculturist.* On the cocoa estates more attention is being paid to the regulation of shade and to pruning. According to the *Annual Report of the Agricultural Department* for 1914, the Entomologist received few enquiries about cocoa pests in that year, and " those observed or reported were from neglected plantations." There is no doubt, however, that insect

pests, particularly Helopeltis, cause considerable loss in places, and the damage is increased by attacks of pod rot (black rot) and canker.

As has been indicated, the natural conditions in Ceylon do not permit of a large extension of cocoa growing. There are, however, areas remaining where the crop may be grown successfully, especially with the provision of proper shelter, and with the development of these areas and the application of more careful methods of cultivation both for plantation and native cocoa, the output should show a considerable and proportionate increase.

Fiji.—The production of cocoa in this Colony is quite small, and among agricultural products the preponderating interest is in sugar, followed by copra and bananas. The exports of cocoa from Fiji have ranged from 113 cwts. in 1911 to 21 cwts. in 1916. Experiments with cocoa have been carried out by the Agricultural Department at Nasinu; but the area devoted to these has been much reduced, and high winds have caused much damage to the trees.

The likelihood of any extension of the very small cocoa industry is remote. The plant is especially likely to suffer severely from the cyclonic storms that are frequent in the islands, whose mountainous nature makes them more suited for the cultivation of other crops.

Seychelles.—In these islands also cocoa production is quite insignificant, chief attention being given to the growing of coconuts, vanilla and rubber, and to the fisheries.

The prospects of cocoa growing in Seychelles may be expressed in the words of the *Annual Report on Agriculture and Crown Lands*, 1913, where it receives attention as a minor industry: "The cacao industry is vanishing in Seychelles, the quantity exported for 1913 amounting to 15 cwts. only. There are many localities where, however, such a very profitable industry should still be carried on. The local variety (Caracas) is attacked by the black rot (*Phytophthora omnivora*) but no preventive treatment has ever been tried. More resistant varieties, such as Venezuelan Criollo and Ceylon Forastero, have become established, and there is no reason why they should not be cultivated in all localities sheltered from the wind and

provided with a good type of soil." Since 1913 the only exports have been 4 cwts. in 1914, and 3 cwts. in 1915.

Mauritius.—This Colony likewise has a very small output of cocoa, the most that has been exported in recent years being 20 cwts. in each of the years 1914 and 1915. The condition and prospects of the industry are thus described in the *Annual Report on the Agricultural Department* for 1913: "The cacao crop at one estate in Grand Port was decidedly satisfactory, and an increase of this cultivation could take place in sheltered parts of that district. Improvements in the methods of preparing the cacao are desirable. The prices realised in the European market were satisfactory, and it is possible that a local market for 'Creole Cacao' could be established." The extent to which the chief crop, sugar, is grown is shown by the fact that in the whole area cultivated, viz. 203,950 acres, sugar takes up 166,016 acres; fibres occupy the next largest area, namely, 20,860 acres; the official returns of the area of cocoa on sugar estates give 25 acres in 1913. Doubtless more land out of the total area of the island, which amounts to about 470,000 acres, might be employed usefully for the raising of crops to fill the place of the large quantity of food-stuffs imported at present; but in any case the conditions do not appear to admit of any very large extension of cocoa growing.

Other British Possessions.—Among other lands in British possession, or where there is a strong British interest British North Borneo, Sarawak, several Pacific islands, the Straits Settlements and the Malay States, Zanzibar and parts of British India, all offer conditions favourable to the growing of cocoa; but the present circumstances of these places are not such as are likely to admit of cocoa cultivation on an economic scale.

Extension of Cocoa Production in the British Empire

The position of cocoa production in the individual British Possessions has been dealt with in the preceding Section. Among those Possessions which have attained importance in respect to the production of cocoa, the West Indies and Ceylon appear to offer the best prospects for

further extension of plantations under European control, and the Gold Coast and the Southern Provinces of Nigeria of those under native farmers in the manner in which they have developed in recent years. In those countries where cocoa growing has hitherto failed to reach a position of importance, namely in British Guiana, British Honduras, Fiji, Seychelles and Mauritius, it will frequently be found to be the case that the existing natural conditions are satisfactory, but labour and transport difficulties have hindered extension. With the provision of adequate labour and increased transport facilities large extensions might be made, particularly in British Guiana and British Honduras.

A matter which must not be lost sight of in considering the question of the future extension of cocoa growing is that of the existing position of the industry in British West Africa. Here it is entirely in the hands of native growers, and its rapid spread may be likened to a mushroom growth, with regard to its probable instability. Selecting the Gold Coast as the most prominent example of this, it will be found that the recent extension is due to the imitation of the procedure of the more agriculturally inclined Akims and Krobos, by the Ashantis, whose antecedents were quite unacquainted with the cultivation of the ground beyond that necessary to raise a few plantains and perhaps colocasia roots in the vicinity of their villages. Now, encouraged by the success of their neighbours, these tribes have cleared the forest and planted cocoa trees, without sufficient knowledge of the requirements of a plantation, and in the expectation that the produce from the tree is marketable in whatever condition it is delivered for sale. This impression, it is true, has been largely encouraged in the past owing to the fact that the demand has been much in advance of the supply. Should, however, a reaction take place, in which the ignorant Ashanti finds his crop unsaleable in the imperfect condition in which he has been accustomed to sell it, the result may be complete abandonment of plantations, and a subsequent difficulty in procuring a resumption of the work if it becomes necessary to re-establish it. A similar condition exists in respect to cocoa cultivation in

Southern Nigeria. The conclusion arrived at from the above is that any extension of cocoa growing in West Africa must be accompanied by the introduction of better cultural and manufacturing methods in respect to the native plantations which already exist as well as those which are in contemplation in the future.

The importance of the West Indies as a whole in the production of cocoa, although the conditions vary in the different islands, warrants the general statement that extension might be made in these possessions. Jamaica offers many situations in which, with the establishment of additional shelter, plantations of cocoa might be made. In Trinidad and Tobago, where the production of cocoa is greater than in any of the other British Possessions except the Gold Coast, the relative importance of the crop to the square mile in the country ranks third highest in the world's cocoa-producing countries. It is therefore hardly to be expected that significant extension of cocoa areas will occur here in the future, more especially on account of the sugar growing industry of Trinidad, which is itself of importance. With respect to the other islands there is apparently more scope. Compared with the West African Possessions, the West Indies possess the advantage of having a number of experienced planters, cognisant of the conditions of cultivation, manufacture and the markets, to enable them to seize opportunities of rapidly regulating their methods in accordance with requirements. The Leeward Islands, Dominica and Montserrat, offer the best conditions for cocoa cultivation, more especially in the coast regions ; but in recent years the cocoa industry has declined in these islands in favour of the cultivation of limes. In Montserrat the cocoa crop is of trivial value in comparison with that of Sea Island cotton and lime products. Grenada is chiefly important for its cocoa, indeed it is only second to San Thomé in the proportionate yield of cocoa to area. The remaining available cocoa land on this island is small, but the natural conditions are eminently suited to the crop, which has a much greater interest in the country than the nutmeg and sugar industries which are found with it. St. Lucia resembles Dominica in that there is a continually increasing interest

in limes, but the conditions in St. Lucia are more generally suited to cocoa plantation, and it may therefore be looked upon as more likely to expand in this direction. Cocoa growing in St. Vincent occupies a position of less importance than that taken by Sea Island cotton and the manufacture of starch from arrowroot and cassava ; the areas in the island where conditions admit of successful cocoa growing have proved to be small in comparison with those from which other more profitable crops may be raised. With regard to the other West Indian islands, the natural conditions and the large interest at present taken in other crops and products render it unlikely that any consideration may be given to the introduction or extension of cocoa growing there.

Although Ceylon was mentioned at the beginning of this section as a field wherein good prospects existed for the extension of cocoa cultivation under European supervision, it must be remembered that the island has been, or is, interested in the production of tea, rubber, cinchona, and minor plantation crops, and is perhaps more rapidly influenced by the remunerative side of any of these in respect to the expansion of their cultivation than any other tropical British Possession. Ceylon, though eminently suitable, and with large tracts available for prospective plantation, is at the present time more closely interested in the extension of rubber and tea than in other plantation work.

The conclusions arrived at from the foregoing are briefly as follows. In the countries where European carefully supervised plantations are most likely to develop, the West Indies offers a field for some expansion. Ceylon, however, which has the same facilities for perfected cultivation and manufacture, is more interested at the present time in other directions, but may become at any time occupied in the greater extension of cocoa growing. Among the British Possessions on the mainland of America, when the obstacles in respect to labour and transport are overcome, both British Guiana and British Honduras present suitable opportunities for cocoa extension. With regard to the native industry in West Africa, this may extend to vast dimensions, but is in an unstable condition, easily

injured by temporary adverse circumstances, for which reason it requires to be most carefully watched.

IV. The World's Consumption of Cocoa

The following table gives the quantities of raw cocoa consumed in the countries mentioned during the three years prior to the war:

	1911. Cwts.	1912. Cwts.	1913. Cwts.
United States	1,160,686	1,303,205	1,330,736
Germany	1,001,031	1,084,293	1,004,927
Holland	463,282	490,545	590,117
United Kingdom	520,568	549,007	564,079
France	538,998	528,193	542,335
Switzerland	193,927	203,572	201,721
Spain	126,804	104,596	121,371
Austria-Hungary	116,140	130,420	121,210
Belgium	108,183	137,630	120,663
Russia	99,207	88,204	103,046
Canada	41,888	59,819	59,045
Italy	43,167	47,872	48,364
Denmark	33,561	33,994	39,801
Norway	20,058	22,164	23,640
Other Countries [1]	106,294	118,104	129,914
Total	4,573,794	4,901,618	5,000,969

[1] *Estimated.*

United States.—As is seen, the United States up to 1913 was the greatest consumer of cocoa, and since then has gone still further ahead, the total importations of the raw product in the year ending June 30, 1917, amounting to over 150,000 tons, valued at eight and a quarter million pounds—that is to say, almost one-half of the total world's production. In the following year it had increased to nearly 180,000 tons, valued at over eight and a half million pounds. The cocoa enters the country mainly through the port of New York, and the bulk of it is consumed in the country, although during 1915 and 1916 there was an exceptionally large re-export trade. The enormous increase in the consumption in the States during recent years is shown in the following table, which gives the total imports and re-exports of raw cocoa during

the years ending June 30, 1913–18, as recorded in the official trade returns:

	1912–13. Cwts.	1913–14. Cwts.	1914–15. Cwts.	1915–16. Cwts.	1916–17. Cwts.	1917–18. Cwts.
Imports	1,250,350	1,573,818	1,717,023	2,171,713	3,023,695	3,562,861
Re-exports	66,415	40,872	258,741	281,111	96,091	113,251
Retained in the country	1,183,935	1,532,946	1,458,282	1,890,602	2,927,604	3,449,610

As a rule, most of the raw cocoa re-exported from the United States is sent to Canada, smaller quantities going to Mexico and, before the war, to Germany. In 1914–15, however, 140,144 cwts. went to Denmark, and 64,695 cwts. to Sweden, whilst in 1915–16 the quantities sent to these countries were 93,114 cwts., and 137,952 cwts., respectively; there were no re-exports to either of these countries in 1912–13 and 1913–14. The re-exports to Europe fell off in 1916–17, when 7,162 cwts. went to Denmark and 8,190 cwts. to Sweden.

Prior to the war the United States obtained its supplies of cocoa chiefly from the West Indies, South America and San Thomé (via Portugal). In 1917–18 the quantities imported from all these countries, except the last, increased, and in addition there was a large import from British West Africa. The imports from the chief countries into the United States during the years ending June 30, 1914 and 1918 are given in the following table:

From	1913–14. Cwts.	1913–14. Percentage of total.	1917–18. Cwts.	1917–18. Percentage of total.
British West Africa	70	—	887,474	24·9
Brazil	230,984	14·7	815,639	22·9
Ecuador	234,998	14·9	685,595	19·2
British West Indies	393,414	25·0	459,277	12·9
Dominican Republic	239,134	15·2	355,814	10·0
Venezuela	35,745	2·3	185,978	8·2
United Kingdom	115,211	7·3	9,269	0·24
Portugal	158,385	10·1	1,204	0·03

Coinciding with the increase in the quantity of raw cocoa imported into the United States, there has been a gradual decrease in the imports of prepared cocoa and a corresponding increase in the exports of locally made cocoa products. The total imports and exports of "cocoa and chocolate, prepared or manufactured (not including

confectionery)" during the years ending June 30, 1913–17 were as follows:

	Imports (foreign merchandise).		Exports[1] (domestic merchandise).
	Quantity.	Value.	Value.
	Cwts.	£	£
1912–13	30,988	164,100	78,403
1913–14	27,647	147,123	70,196
1914–15	21,675	121,857	402,951
1915–16	20,957	127,576	347,637
1916–17	16,335	115,237	719,067
1917–18	2,428	19,770	1,365,500

[1] *Quantity exported not recorded in Official Trade Returns.*

In each of the above years the prepared cocoa and chocolate came mainly from the Netherlands, smaller quantities being obtained from the United Kingdom, Switzerland and, in 1912–13 and 1913–14, from Germany. Most of the exports of cocoa and chocolate prepared in the United States went in normal times to Canada and other countries in America, but since 1914 it has come mainly to Europe, the chief countries of destination being in 1914–15 Denmark (£179,753), United Kingdom (£64,478) and Netherlands (£48,424); in 1915–16 United Kingdom (£134,041); and in 1916–17 United Kingdom (£330,013) and France (£175,637).

Germany.—Germany up to 1913 took a fluctuating quantity of raw cocoa amounting to 10,000 or 15,000 tons below the consumption of the United States. Of the amount imported in 1913, nearly one-third, or 317,044 cwts., came from British Possessions, mainly West Africa; the other chief countries of supply were Portuguese West Africa, Ecuador and Brazil. Cocoa entered Germany by the port of Hamburg, which for some years prior to the war was the chief port of entry for cocoa in Europe, except in 1909 and 1910, when Havre occupied the premier position.

United Kingdom.—The statistics of the cocoa trade in the United Kingdom during recent years are summarised in the tables on the following page. Details of the trade are given in a later section (pp. 83–95).

London is the chief port of entry for cocoa in the United Kingdom. In 1914 it held the fourth place among the cocoa importing ports of the world, its annual receipt

Cocoa Imports into the United Kingdom

		1912.	1913.	1914.	1915.	1916.	1917.
Raw cocoa	cwts.	672,113	699,639	834,922	1,635,549	1,776,239	1,158,160
	£	1,948,889	2,282,573	2,487,937	5,931,928	6,758,409	3,569,847
Husks and shells	cwts.	14,928	6,975	8,422	1,433	698	—
	£	3,056	1,552	1,455	260	64	—
Cocoa butter	cwts.	9,537	18,241	30,237	11,978	19,242	1,349
	£	58,007	122,159	204,069	89,224	169,600	12,676
Cocoa and chocolate preparations, including chocolate confectionery	cwts.	211,345	246,482	205,083	327,685	266,740	129,036
	£	1,604,274	1,866,992	1,523,630	2,428,520	2,300,731	959,646

Cocoa Retained in the United Kingdom[1]

		1912.	1913.	1914.	1915.	1916.	1917.
Raw cocoa	cwts.	549,007	564,079	592,348	1,088,114	1,295,162	1,061,602
	£	1,570,922	1,807,560	1,743,143	3,795,604	4,850,696	3,257,375
Husks and shells	cwts.	14,319	6,840	8,298	1,433	698	—
	£	2,928	1,524	1,424	260	64	—
Cocoa butter	cwts.	9,484	18,142	29,666	9,685	8,609	—3,031[2]
	£	57,621	121,465	200,235	71,004	74,213	—35,208[2]
Cocoa and chocolate preparations, including chocolate confectionery	cwts.	206,122	240,477	195,565	279,657	227,578	122,466
	£	1,556,499	1,811,614	1,448,102	2,089,561	1,990,436	908,987

[1] *Total imports, less exports of foreign and colonial produce.* [2] *Re-exports in excess of imports.*

Cocoa Exported, Produce and Manufacture of the United Kingdom

		1912.	1913.	1914.	1915.	1916.	1917.
Cocoa preparations made either in bond or not	cwts.	157,686	164,589	150,945	155,621	183,928	102,982
	£	982,555	1,038,949	960,945	1,036,556	1,464,786	753,792

Cocoa Retained for Home Consumption, United Kingdom[1]

		1912.	1913.	1914.	1915.	1916.	1917.
Raw cocoa	cwts.	492,201	463,707	498,505	805,394	585,923	825,868
Cocoa preparations	,,	212,006	235,166	191,992	276,100	197,160	93,764

[1] *Total entered, less drawbacks.*

of cocoa being exceeded by Hamburg, Havre and New York in the order named.

France.—In 1913 France imported for consumption 542,000 cwts. of raw cocoa, valued at £1,930,000. Of this quantity 110,600 cwts. came from British West Africa and 90,700 cwts. from the British West Indies. Other chief countries supplying raw cocoa to France in that year were Brazil (83,900 cwts.), Venezuela (69,500 cwts.), Dominica (46,500 cwts.), Ecuador (41,300 cwts.) and West Africa, other than British (32,300 cwts.). In addition 58,000 cwts. of cocoa products, including chocolate, valued at £340,000, were imported for consumption. As has been indicated already, Havre is the chief French port of entry for cocoa.

Holland.—The net imports of raw cocoa into Holland in 1913, that is, the total imports less re-exports, amounted to 590,000 cwts., valued at £1,634,000. The total imports in that year were 848,000 cwts., of which nearly 90 per cent. came through other European countries, chiefly Germany, United Kingdom, Portugal, France and Belgium. Of the raw cocoa imported direct from producing countries, 41,700 cwts. came from Java, 23,100 cwts. from the West Indies and 22,500 cwts. from South America. Most of the cocoa enters the country through Amsterdam, which receives the greater part of the cocoa grown in Java.

Switzerland.—This country ranks sixth amongst countries consuming raw cocoa, a large part of which is used in making cocoa preparations for export. Of the 201,000 cwts. of raw cocoa imported for consumption in 1913, 49,500 cwts. came from Brazil, 27,900 cwts. from Colombia, 23,800 cwts. from other South American countries, 47,800 cwts. from Central America and 46,800 cwts. from Africa.

Austria-Hungary.—The British West Indies supplied more than one-half the raw cocoa imported into Austria-Hungary in 1913, the figure being 70,400 cwts. out of a total of 121,200 cwts. Brazil was the next largest contributor, with 12,700 cwts., whilst Germany and Switzerland supplied between 10,000 and 11,000 cwts. each in 1913.

Belgium.—As in the case of Holland, most of the raw cocoa imported into Belgium comes through other European countries; about one-half of the total imports is re-exported. The net imports in 1912 and 1913 amounted to 138,000 cwts. and 121,000 cwts. respectively, whilst the total quantity imported in the former year was 255,000 cwts., of which over 80 per cent. came via the United Kingdom, Portugal, France, Germany and Holland. The most important producing country from which raw cocoa was imported in 1912 was the Belgian Congo (19,500 cwts.).

Spain.—In 1913 Spain imported 121,400 cwts. of raw cocoa, the chief countries of origin being Fernando Po (55,600 cwts.), Ecuador (30,700 cwts.) and Venezuela (30,300 cwts.).

British Dominions.—Among the British Possessions, Canada is first as a consumer of cocoa, the total quantity and value of the imports of raw cocoa and cocoa preparations in recent years being as follows: 1912–13, 99,600 cwts., £408,490; 1913–14, 131,000 cwts., £569,200; 1914–15, 105,300 cwts., £446,000; 1915–16, 104,600 cwts., £506,200. In the same years the imports of raw cocoa amounted to 59,000, 61,500, 51,400 and 59,800 cwts. respectively. In 1912-13 over 70 per cent. of the raw cocoa came from the United States, but in succeeding years the importation from the British West Indies increased greatly, and in 1915–16 Canada imported 29,900 cwts. from the United States (50 per cent. of the total), 21,000 cwts. from the British West Indies (35 per cent.), and 7,900 cwts. from the United Kingdom (12 per cent.). The cocoa preparations imported into Canada come mainly from the United Kingdom.

The consumption of raw cocoa in Australia has increased considerably in recent years, the imports rising from just over 9,000 cwts., valued at £37,300, in 1912, to 29,500 cwts., valued at £115,700, in 1915–16. In the latter year the cocoa came mainly from the West Indies (via the United Kingdom) and Samoa. Most of the cocoa, however, enters the Commonwealth in the form of cocoa preparations, of which 58,300 cwts., valued at £484,100, were imported in 1915–16.

The quantity of raw cocoa imported into the Union of South Africa, although still comparatively small, is rapidly increasing. In 1912 the imports amounted to 650 cwts., valued at £2,200, and in 1917 to 8,250 cwts., valued at £22,900. During the same period, however, the imports of cocoa preparations have been reduced, falling from 5,900 cwts., valued at £54,000, in 1912, to 2,200 cwts., valued at £21,800, in 1917. In recent years the raw cocoa imported into the Union has come mainly from Ceylon and Portuguese West Africa.

V. Cocoa Trade of the United Kingdom

Imports

Before the war the United Kingdom not only received supplies of raw cocoa direct from the countries where it is grown, but large quantities were re-exported to this country from foreign non-producing countries. Consideration of the supply of raw cocoa from all the chief sources (both producing and non-producing) shows that before the war the United Kingdom was dependent on foreign sources for about one-half of its raw cocoa; thus in 1913, in a total importation valued at nearly £2,200,000, the share of foreign countries was over £1,040,000; and the corresponding figures for 1912 were about £1,870,000 and £950,000. In the former year the value of the imports from foreign producing countries (chiefly Brazil and Ecuador) was over £800,000; the chief non-producing foreign countries supplying the raw product to this country were Portugal and Germany.

These considerations do not, however, indicate fully the extent to which the United Kingdom was dependent upon foreign sources for cocoa produce. The imports of preparations of cocoa, which are supplied entirely by foreign countries, were in 1913 worth nearly as much as all the imports of raw cocoa, and nearly £1,950,000 went to those countries for such products, as compared with nearly £1,200,000 for raw cocoa from British Possessions. The dependence in that year of the United Kingdom on foreign

countries for cocoa and cocoa products is further emphasised when it is stated that, of a total sum of £4,145,693 paid for such products, £2,987,547, or nearly three-quarters, went to foreign countries.

As part of these sums accrues again to this country through the re-exportation to some extent of consigned imports, the subject must be completed by considering the proportions in the total value taken by the different sources of supply. In 1913 about 87 per cent. in value of the cocoa imported was retained in the United Kingdom; and, of this proportion, worth about £3,625,000, a sum of nearly £890,000 went for raw cocoa from British Possessions, £844,500 for raw cocoa from foreign countries, and just over £1,890,000 for preparations of cocoa, which, as has been stated, come entirely from foreign countries. A review of these figures shows that, for the cocoa and cocoa products needed for use in the country, the United Kingdom was dependent on foreign countries for 75·5 per cent. of the value imported; the corresponding figure in the case of total imports is 72·6 per cent.

The following table gives in terms of value the percentages of raw cocoa and cocoa products supplied by the different sources for consumption in the United Kingdom in 1913:

British Possessions	24·5
Brazil and Ecuador	15·0
Other foreign producing countries	2·3
Foreign non-producing countries, raw cocoa	6·0
Foreign non-producing countries, cocoa products	52·2

The cocoa products consist chiefly of cocoa powder, chocolate and chocolate confections and cocoa butter and, as is seen, their purchase accounts for more than one-half of the total expenditure on cocoa and cocoa products in the United Kingdom.

The percentages from the chief sources of supply, in terms of value, of raw cocoa retained in the United Kingdom in 1913 were as follows:

British Possessions	51·3
Brazil and Ecuador	31·5
Other chief foreign producing countries	4·8
Chief foreign non-producing countries	12·4

In the years immediately preceding 1914 the chief source of supply of British-grown raw cocoa was the West Indies—the Gold Coast, Ceylon and Nigeria coming next in order of value. Of the principal foreign producing countries, other than Brazil and Ecuador, which supplied raw cocoa during that period, the chief were German West Africa (the Cameroons and Togoland), San Domingo and Venezuela. The non-producing countries that ship raw cocoa to the United Kingdom in any quantity are all European, viz.: Portugal, Germany, the Netherlands and France, and up to 1914 the export from the second-named country was increasing rapidly. It is through Portugal that a large quantity of San Thomé cocoa reaches these islands.

The total quantity of raw cocoa imported to the United Kingdom from the chief British producing countries in 1913, and the quantity retained here, are shown in the following table:

	Imported.		Retained.	
From	*Cwts.*	*Percentage of output.*	*Cwts.*	*Percentage of output.*
Gold Coast . . .	166,758	16·5	158,607	15·7
British West Indies .	143,157	23·6	113,149	18·6
Nigeria . . .	14,711	20·3	12,659	17·5
Ceylon . . .	45,099	65·8	7,619	11·1

The position may be summarised as follows: Assuming 1913 to be a normal pre-war year, the British Possessions produced in that year about two and a half times as much raw cocoa as the United Kingdom imported from all sources. Again, only about one-half of the importations of raw cocoa into the United Kingdom came direct from her own Colonies and Protectorates, in spite of the ample supplies available, the other half being from foreign countries. The apparent uneconomical situation is further emphasised by the fact that foreign non-producing countries manufactured the raw product of British Possessions, and largely supplied the manufactured article to the United Kingdom.

During the war the situation altered, and a continually increasing amount of raw cocoa was obtained from British Possessions, as the following figures show:

	Total value of raw cocoa imported.	From British Possessions.	
	£	£	*Per cent.*
1913	2,198,918	1,158,146	52·7
1914	2,438,913	1,204,078	49·4
1915	5,746,954	3,545,888	61·7
1916	6,498,155	4,417,389	68·0
1917	3,498,194	3,010,442	86·0

If the value of the imports of cocoa preparations be taken into account the percentage shows a still further improvement, the figures being as follows:

	Total value of raw cocoa and cocoa products imported.	From British Possessions (all raw cocoa).	
	£	£	*Per cent.*
1913	4,145,693	1,158,146	27·4
1914	4,108,429	1,204,078	29·3
1915	8,067,893	3,545,588	43·9
1916	8,714,441	4,417,389	50·8
1917	4,144,932	3,010,442	72·6

Not only has the United Kingdom imported more cocoa from British Possessions during the war, but it has taken, and also retained, a larger proportion of their total output. The following figures showing the quantity of cocoa imported from the chief British producing countries in 1916, and the quantity retained should be compared with the similar table on page 85, giving the corresponding figures for 1913:

From	Imported.		Retained.	
	Cwts.	*Percentage of output.*	*Cwts.*	*Percentage of output.*
Gold Coast . . .	846,558	58·6	590,139	41·6
British West Indies .	226,556	33·5	181,196	26·9
Nigeria	106,650	59·6	66,746	37·3
Ceylon	38,378	52·4	16,853	23·0

A detailed statement of the quantities and values of cocoa and preparations of cocoa (including cocoa butter) imported into the United Kingdom from the chief countries in the years 1913–17, and the quantities and values retained here, is given in the tables on pages 88 and 89.

Exports

In recent normal years seven or eight times as much raw cocoa has been exported from the United Kingdom to foreign countries as to the British Possessions; and this was only to be expected, in view of the large demand for cocoa for the manufacture of cocoa preparations that existed in foreign countries such as Germany, the United States and the Netherlands. In this way the value of the cocoa shipped to foreign countries in 1913 was £416,122 against a value of £58,891 to British Possessions. In that year 20 per cent., in terms of value, of the exports of raw cocoa to foreign countries went to Germany, 17·6 per cent. to the United States, 15·1 per cent. to the Netherlands, 14·2 per cent. to Russia, 11·1 per cent. to Belgium and 11·0 per cent. to Mexico. In 1915, when supplies to Germany had ceased, and those to Belgium were reduced to 0·2 per cent., a large proportion of the cocoa went to the Scandinavian countries, nearly 23 per cent. of the exports to foreign countries going to Sweden alone. Other chief customers in that year were the Netherlands, 21·5 per cent., Russia, 16·4 per cent., and United States 10·4 per cent. The total exports to foreign countries in 1915 were valued at £2,067,372. In 1916, when the value of the total exports to foreign countries amounted to £1,832,149, the export to Scandinavian countries almost ceased and the chief foreign countries receiving raw cocoa from the United Kingdom were Russia, 24·1 per cent.; Netherlands, 24·0 per cent.; United States, 19·4 per cent.; Italy, 11·0 per cent.; and Switzerland, 9·5 per cent. The exports to foreign countries fell considerably in 1917, being valued at only £295,628, of which 52·7 per cent. went to the United States, 13·2 per cent. to the Netherlands, 12·1 per cent. to France, and 8·9 per cent. to Italy.

The position in regard to the British Possessions is best defined after a consideration of the returns of the shipments of cocoa preparations taken in the broad sense of the term; for there is as yet no appreciable demand in these countries for raw cocoa for manufacture. In 1912 and 1913 the United Kingdom sent 23 or 24 times as

Imports of Raw Cocoa into the United Kingdom from Chief Producing Countries

From		1913. Imported.	1913. Retained.	1914. Imported.	1914. Retained.	1915. Imported.	1915. Retained.	1916. Imported.	1916. Retained.	1917. Imported.	1917. Retained.
Gold Coast	cwts.	166,758	158,607	165,185	145,304	623,000	393,173	846,558	590,139	756,730	691,130
	£	470,937	447,144	450,454	398,780	2,100,644	1,244,919	2,944,667	2,015,149	2,147,562	1,945,948
British West Indies	cwts.	143,157	113,149	196,795	144,371	232,787	140,165	226,556	181,196	148,286	147,018
	£	480,847	378,716	589,118	429,917	894,100	512,843	957,441	751,196	582,068	576,857
Ecuador	cwts.	79,671	62,506	203,808	136,165	215,406	141,853	208,291	146,301	36,305	35,302
	£	284,694	224,044	633,441	418,677	872,867	575,992	933,739	640,085	146,866	142,218
Brazil	cwts.	115,145	95,030	118,291	72,574	208,229	179,176	111,798	101,977	37,239	33,014
	£	387,939	321,384	345,120	214,763	773,232	667,614	451,170	411,230	123,489	105,154
Nigeria	cwts.	14,711	12,659	21,814	16,588	102,940	74,208	106,650	66,746	69,861	54,351
	£	41,701	35,646	58,786	45,392	337,231	231,690	362,172	227,384	193,916	149,015
German West Africa	cwts.	14,087	12,246	4,839	2,639	54,072	45,362	46,974	41,572	45,132	45,132
	£	43,895	37,724	12,930	6,975	206,794	176,448	183,257	162,652	144,827	144,827
Ceylon	cwts.	45,099	7,619	29,502	9,345	60,105	27,939	38,378	16,853	21,767	19,216
	£	164,661	27,696	105,720	34,078	213,613	80,039	153,109	53,235	86,896	75,453
Venezuela	cwts.	6,483	2,368	7,421	1	7,325	4,106	12,346	8,349	226	1
	£	27,565	10,158	26,411	1	31,940	15,572	60,979	39,664	1,257	1
German Pacific Possessions	cwts.	3,472	568	4,387	2,928	14,835	12,093	12,491	8,831	3,313	2,065
	£	11,473	81	14,615	9,272	54,714	43,269	50,372	33,359	12,266	7,085
Portuguese West Africa	cwts.	3,806	1,723	3,715	1	19,512	7,571	4,249	1	796	1
	£	11,688	4,404	9,731	1	70,467	24,164	16,319	1	2,208	1
Java	cwts.	5,570	1,352	2,469	1,258	6,362	1,691	1,680	1	2,340	1,766
	£	22,415	5,669	9,131	4,711	24,804	4,809	6,833	1	9,397	6,661
Colombia	cwts.	607	540	642	181	3,477	2,600	644	644	481	481
	£	2,076	1,871	2,053	671	12,891	9,531	2,762	2,762	2,372	2,372
Haiti	cwts.	501	281	91	1	154	154	433	433	—	—
	£	1,350	784	267	1	658	658	1,768	1,768	—	—
Spanish West Africa (including Fernando Po)	cwts.	145	123	219	168	198	137	260	251	456	452
	£	378	306	520	408	770	582	950	910	1,368	1,354
San Domingo	cwts.	6,654	6,282	2,683	2,101	760	1	235	173	—	—
	£	20,180	19,020	7,836	6,282	2,844	1	628	355	—	—
Dutch Guiana	cwts.	396	396	1,415	738	2,216	1,752	—	—	—	—
	£	1,076	1,076	4,508	2,278	8,765	7,017	—	—	—	—

Imports of Raw Cocoa and Cocoa Products into the United Kingdom from Countries not producing Cocoa

Switzerland: Preparations of cocoa, etc.[2]	cwts.	96,919	94,317	95,924	89,979	208,371	179,079	166,130	140,032	44,640	41,709
	£	804,202	784,668	812,382	767,011	1,732,528	1,509,602	1,672,391	1,447,517	535,752	506,997
Netherlands: Raw cocoa	cwts.	5,429	5,129	4,223	4,073	½	1	77	1	33	33
	£	16,943	15,721	13,960	13,449	1	1	351	1	151	151
Preparations of cocoa, etc.	cwts.	115,536	112,402	86,724	84,139	76,483	71,402	49,787	44,496	10,925	10,663
	£	857,421	823,450	579,833	554,284	511,782	459,813	371,405	330,186	95,097	91,811
Cocoa butter	cwts.	17,256	17,157	27,240	26,669	8,457	7,681	18,009	8,711	1,317	3,053
	£	114,314	113,620	185,082	181,249	63,318	57,349	157,905	77,351	11,324	36,455
Portugal: Raw cocoa	cwts.	22,819	21,722	21,567	21,405	26,011	18,691	86,314	77,900	12,997	9,817
	£	73,527	69,878	61,472	61,007	100,290	70,313	338,260	299,884	43,373	29,963
France: Raw cocoa	cwts.	8,735	7,937	14,225	13,418	9,592	6,885	6,971	5,664	24	24
	£	33,442	29,738	43,699	41,418	40,929	31,041	33,378	27,076	178	178
Preparations of cocoa, etc.[2]	cwts.	1,897	1,819	2,742	2,603	1,811	1,533	1,923	1,897	342	342
	£	17,293	16,753	21,972	20,530	13,311	10,885	14,585	14,373	4,565	4,565
Germany: Raw cocoa	cwts.	31,196	30,812	15,927	15,384	—	—	—	—	—	—
	£	102,131	100,811	49,191	47,396	—	—	—	—	—	—
Preparations of cocoa, etc.[2]	cwts.	27,274	27,140	9,056	8,931	—	—	—	—	—	—
	£	153,545	152,527	70,247	69,410	—	—	—	—	—	—

Summary of Values (£) of Chief Importations of Raw Cocoa and Cocoa Products

Raw cocoa:										
British Possessions	1,158,146	889,202	1,204,078	908,167	3,545,588	2,069,491	4,417,389	3,046,964	3,010,442	2,747,273
Foreign countries, producing	814,729	626,521	1,066,563	664,037	2,060,146	1,526,040	1,708,777	1,292,785	444,050	409,729
" " non-producing	226,043	216,148	168,272	163,270	141,220	101,354	371,989	326,960	43,702	30,292
" " Total	1,040,772	842,669	1,234,835	827,307	2,201,366	1,627,394	2,080,766	1,619,745	487,752	441,021
Total	2,198,918	1,731,871	2,438,913	1,735,474	5,746,954	3,696,885	6,498,115	4,666,709	3,498,194	3,188,294
Cocoa preparations (all foreign)	1,946,775	1,891,018	1,669,516	1,592,484	2,320,939	2,037,649	2,216,286	1,869,427	646,738	639,828
Total cocoa and cocoa products	4,145,693	3,622,889	4,108,429	3,327,958	8,067,893	5,734,534	8,714,441	6,536,136	4,144,932	3,828,122

[1] *Re-exports greater than consigned imports.*

[2] *Including cocoa butter.*

much, of cocoa preparations made at home, as of such preparations made in foreign countries; whilst the abnormal conditions that obtained after the middle of 1914 caused a fall in that year to nearly 15 times as much. Again, the United Kingdom sent in those years a far greater proportion of its home-made cocoa preparations to the British Possessions than to foreign countries, as might have been expected; in fact, 12 to 13 times as much in 1912 and 1913 and 19 times as much in 1914.

The following table[1] shows in terms of value percentages the export from the United Kingdom in British Possessions of (1) raw cocoa and cocoa preparations made in the United Kingdom, (2) foreign cocoa preparations, (3) raw cocoa and preparations from all sources:

	Raw cocoa and cocoa preparations made in the United Kingdom.			Foreign cocoa preparations.			Raw cocoa and cocoa preparations from all sources.		
	1912.	1913.	1914.	1912.	1913.	1914.	1912.	1913.	1914.
Australia	41·7	39·3	45·2	12·0	14·5	24·4	40·8	38·3	43·9
Canada	25·5	29·2	23·4	—	—	—	24·7	28·0	21·9
New Zealand	9·3	8·3	9·7	16·1	14·4	34·3	9·5	8·6	11·2
Cape Colony	6·6	6·4	6·2	24·2	25·6	16·7	7·2	7·1	7·0
India	6·8	6·5	6·5	13·2	10·0	3·5	7·0	6·7	6·3
Transvaal	3·4	3·7	3·2	11·5	18·1	15·6	3·7	4·3	4·0
Natal	3·2	3·0	2·8	14·0	14·0	5·0	3·5	3·4	2·9
Channel Islands	1·5	1·4	1·5	—	—	—	—	—	—
Newfoundland and Labrador Coast	0·8	1·1	0·5	—	—	—	—	—	—
British W. Indies	1·3	1·0	1·1	—	—	—	—	—	—
Hong Kong	—	—	—	4·8	2·1	0·1	—	—	—
Straits Settlements	—	—	—	4·2	1·4	0·6	—	—	—

Among these countries, raw cocoa is only shipped from the United Kingdom in any quantity to Australia, Canada and New Zealand, the quantities thus exported in 1913 amounting only to 778 tons, valued at £56,692. The chief trade with the Possessions is in cocoa preparations made in the United Kingdom; they were worth £912,536 in 1913, out of a total export of cocoa and preparations to British Possessions valued at £1,015,501. Nearly all these countries take from the United Kingdom a certain quantity of re-exports of cocoa preparations of foreign origin, the total value amounting in 1913 to £44,074.

Details of the exports of raw cocoa and cocoa prepara-

[1] Blanks are placed in this table where the proportions are very small. The figures for 1914 are naturally inclined to be abnormal.

tions from the United Kingdom to the chief British Possessions and foreign countries in recent years are given in the table on pages 92 and 93.

The Extension of Cocoa Exports

The following information will give some indication of the prospects of the cocoa trade of the United Kingdom with the chief countries of the British Empire and certain foreign countries, with regard to the export of cocoa and cocoa products.

Australia.—This country is now chief among British Possessions importing from the United Kingdom raw cocoa and cocoa preparations made in England. In raw cocoa there has been a steadily increasing trade which since 1909 has changed in value from £21,584 to £31,824 in 1913. There is also a steadily increasing demand for cocoa preparations made in the United Kingdom—a demand which is very large compared with that for similar foreign preparations; and altogether the prospects of increasing imports of both cocoa and cocoa products are good.

Canada.—In this case the percentage of raw cocoa and English cocoa preparations is much less, and the imports of foreign cocoa manufactures from the United Kingdom are negligible. Canada, however, offers a good market for British raw cocoa, as well as for English cocoa manufactures, although in the latter case especially there is to be expected much competition with similar products imported from the United States.

New Zealand.—The imports of raw cocoa and English cocoa preparations are much smaller than in the case of Australia; and there has been an increasing trade with the United Kingdom in foreign cocoa preparations. It is in the direction of English manufactures of cocoa that New Zealand offers the greatest scope.

South African Countries.—The position in these countries is similar to that in New Zealand; there is a comparatively large import from the United Kingdom of foreign cocoa preparations, for which might be substituted preparations of British origin.

Other British Countries.—British India, Hong Kong and

Exports of Raw Cocoa and Cocoa Preparations from United Kingdom

Country	Item	1913. Cwts.	1913. £	1914. Cwts.	1914. £	1915. Cwts.	1915. £	1916. Cwts.	1916. £	1917. Cwts.	1917. £
Union of South Africa	Raw cocoa	601	2,191	518	1,685	437	1,907	902	3,756	28	92
	Cocoa preparations, United Kingdom	17,454	120,251	14,878	103,171	18,545	132,587	17,982	154,771	2,711	24,101
	„ „ foreign	2,276	20,936	2,332	20,730	4,670	40,749	1,887	17,682	584	5,820
	Total value		143,378		125,586		175,243		176,209		30,013
Australia	Raw cocoa	8,793	31,824	6,314	19,137	10,821	44,571	11,202	49,282	1,129	4,389
	Cocoa preparations, United Kingdom	51,121	327,038	56,016	364,024	47,185	321,654	51,861	414,893	7,854	56,238
	„ „ foreign	522	5,249	1,675	13,560	15,778	122,544	16,157	139,025	949	9,214
	Total value		364,111		396,721		488,769		603,200		69,841
Canada	Raw cocoa	5,684	21,125	4,192	15,347	4,199	16,749	9,651	39,182	3,472	12,081
	Cocoa preparations, United Kingdom	42,886	244,693	31,092	182,659	18,582	112,878	16,268	113,376	22,573	154,824
	„ „ foreign	52	506	17	211	263	1,565	19	197	—	—
	Total value		266,324		198,217		131,192		152,755		166,905
New Zealand	Raw cocoa	1,084	3,743	1,549	4,573	1,409	5,703	806	3,328	68	252
	Cocoa preparations, United Kingdom	10,820	72,421	11,475	77,336	12,850	100,120	14,593	123,002	5,996	37,899
	„ „ foreign	572	5,243	2,357	19,066	8,293	65,500	5,469	47,103	237	2,326
	Total value		81,407		100,975		171,323		173,433		40,477
British India	Cocoa preparations, United Kingdom	8,669	59,721	7,600	54,663	6,554	48,571	11,872	102,907	1,992	19,279
	„ „ foreign	300	3,622	143	1,845	192	2,402	178	2,376	37	509
	Total value		63,343		56,508		50,973		105,283		19,788
Other British Possessions	Raw cocoa	¾	8	3	12	1	22	4	16	5	30
	Cocoa preparations, United Kingdom[1]	14,642	88,412	12,313	73,755	15,482	96,764	21,162	167,180	5,161	47,607
	„ „ foreign[2]	959	8,518	990	7,739	1,483	13,167	2,249	21,772	757	7,237
	Total value		96,938		81,506		109,953		188,968		54,874
Russia	Raw cocoa	16,826	59,274	23,950	76,877	82,215	338,917	91,510	442,497	33	162
	Cocoa preparations, United Kingdom	362	3,219	781	5,790	2,080	15,878	11,093	113,127	6,633	57,395
	„ „ foreign	10	42	162	1,302	4,161	28,791	8,588	47,716	1,201	5,718
	Total value		62,535		83,969		383,586		603,340		63,275
Netherlands	Raw cocoa	19,690	62,720	108,959	325,900	115,524	445,545	111,424	441,285	9,828	39,097
	Cocoa preparations, United Kingdom	525	2,940	1,513	6,346	2,117	7,549	23	138	—	—
	„ „ foreign	246	860	930	3,255	3,102	9,665	363	1,735	—	—
	Total value		66,520		335,501		462,759		443,158		39,097
United States	Raw cocoa	19,191	73,245	7,681	27,008	56,310	215,506	99,448	357,084	50,919	155,701
	Cocoa preparations, United Kingdom	709	4,574	1,065	6,319	760	4,249	313	2,280	51	535
	Total value		77,819		33,327		219,755		359,364		156,236
Italy	Raw cocoa	1,666	5,852	4,115	12,045	16,336	58,251	56,947	202,260	8,409	26,268
	Cocoa preparations, United Kingdom	104	632	417	2,761	2,904	23,968	3,583	37,874	4,534	35,701
	Total value		6,484		14,806		82,219		240,134		61,969

Belgium	Raw cocoa	13,872	46,133	11,855	35,807	1,204	4,902	—	—	—	—
	Cocoa preparations, United Kingdom	728	3,922	300	1,379	159	624	3,675	15,786	12	65
	Total value		50,055		37,186		5,526		15,786		65
Switzerland	Raw cocoa	831	2,685	5,733	16,311	21,726	66,893	47,073	174,722	4,087	13,294
	Cocoa preparations, United Kingdom	7	26	11	45	2,440	20,440	5,868	54,825	16,399	110,738
	" " foreign	233	1,512	40	216	—	—	135	877	—	—
	Total value		4,223		16,572		87,333		230,424		124,032
Sweden	Raw cocoa	1,336	4,692	21,461	67,368	122,921	473,304	7,683	32,716	—	—
France	Raw cocoa	1,177	4,251	3,687	9,126	7,364	26,423	8,478	29,385	11,859	35,756
	Cocoa preparations, United Kingdom	99	729	317	1,571	15,836	79,460	16,131	81,056	25,673	183,087
	" " foreign	34	203	28	237	5,164	24,951	1,447	8,897	2,239	14,198
	Total value		5,183		10,934		130,834		119,338		233,041
Argentine Republic	Raw cocoa	261	1,120	416	1,572	1,144	5,330	751	3,766	218	1,000
	Cocoa preparations, United Kingdom	2,098	17,764	1,133	9,498	1,332	12,033	1,321	12,444	212	1,829
	Total value		18,884		11,070		17,363		16,210		2,829
Mexico	Raw cocoa	12,285	45,807	61	240	—	—	—	—	—	—
Germany	Raw cocoa	24,372	83,537	16,471	51,611	—	—	—	—	—	—
Austria-Hungary	Raw cocoa	4,422	14,524	2,094	6,860	—	—	—	—	—	—
Other foreign countries	Raw cocoa [3]	3,459	12,282	23,514	73,315	108,807	432,301	35,198	148,434	6,503	24,350
	Cocoa preparations, United Kingdom [4]	14,365	92,607	12,034	71,628	8,795	59,781	8,183	71,127	3,415	26,825
	" " foreign [5]	774	8,372	823	7,135	4,916	29,543	2,669	22,896	698	7,163
	Total value		113,261		152,078		521,625		242,457		58,338

Summary of Values (£)

		1913.	1914.	1915.	1916.	1917.
To British Possessions	Raw cocoa	58,891	40,754	68,952	95,564	16,844
	Cocoa preparations, United Kingdom	912,536	855,608	812,574	1,076,129	339,948
	" " foreign	44,074	63,151	245,927	228,155	25,106
	Total	1,015,501	959,513	1,127,453	1,399,848	381,898
To foreign countries	Raw cocoa	416,122	704,040	2,067,372	1,832,149	295,628
	Cocoa preparations, United Kingdom	126,413	105,337	223,982	388,657	416,175
	" " foreign	10,989	12,145	92,950	82,121	27,079
	Total	553,524	821,522	2,384,304	2,302,927	738,882
	Total value of all exports of cocoa, etc.	1,569,025	1,781,035	3,511,757	3,702,775	1,120,780

[1] *Channel Islands, Straits Settlements, Ceylon, Hong Kong, British West Indies, Egypt, etc.*
[2] *British East Africa, British West Indies, Channel Islands, Egypt, British West Africa, Rhodesia, etc.* [3] *Norway, Denmark, Spain, etc.*
[4] *Java, Portugal, Canary Islands, Turkey and Crete, China, Japan, Philippine Islands, Porto Rico, Panama, Peru, Chile, Uruguay, etc.*
[5] *Norway, Denmark, Portuguese East Africa, Porto Rico, Cuba, Chile, Brazil, Japan, etc.*

the Straits Settlements take appreciable amounts of cocoa preparations from the United Kingdom; but these are nearly all re-exports of foreign manufactures. They may doubtless share to an important extent in the general market for British cocoa preparations.

Germany.—Here, the trade has existed chiefly in respect of re-exports of raw cocoa; that in cocoa preparations has been very small indeed. Germany held until 1914 the place of chief importer of raw cocoa from the United Kingdom. It is not possible, however, at present to foresee the trend of the future export trade with this country.

United States.—This country has closely followed Germany as an importer of raw cocoa from the United Kingdom, and, like that country, has taken only infinitesimal quantities of manufactured products. The re-exports of raw cocoa to the United States increased largely during the war, more than half the total being sent there in 1917, and there is reason to believe that this trade will continue.

Netherlands.—The value of the imports of raw cocoa from England has generally almost equalled, and sometimes exceeded that of the shipments to the United States. The conditions of trade in the latter half of 1914 and in 1916 led to a very great increase in the share of the Netherlands in the raw cocoa exports, but in 1917 the exports fell to below the pre-war figure. The Netherlands, like the two countries just dealt with, do not take any appreciable quantity of British cocoa manufactures.

Russia.—As in the case of the preceding foreign countries, the trade before the war was almost entirely concerned with re-exports of raw cocoa from the United Kingdom. The trade in this had been rapidly increasing, and had become nearly equal to that of the Netherlands, whilst in 1916 nearly one-fifth of the total re-exports of raw cocoa went to Russia. The abnormal conditions in 1917, however, led to the almost complete cessation of this trade. During the war there was a very large increase in the export to Russia of cocoa preparations. There is no doubt that the increasing demand for cocoa products that exists in the country affords a very favourable opportunity for a large expansion in the cocoa

production of the British Empire, in the direction of Russia, when the conditions there become more settled.

Belgium.—Here the demand for raw cocoa has been similar in quantity to that of Russia. Owing to the war it virtually ceased in recent years ; but the magnitude of the import trade that has existed indicates that the country will in time provide again a large opening for raw cocoa from British Possessions.

Other Foreign Countries.—Of these, the Argentine Republic, Porto Rico, Chile, Uruguay, Turkey and Panama have shown a demand mainly for cocoa preparations of British manufacture ; and the trade in these products that has existed gives hope that more normal conditions may bring about an increase in the export of such products to most of them. Mexico is an example of a country that produces cocoa, but has nevertheless exhibited a strong demand for raw cocoa re-exported from England ; the trade ceased during the war, however, and may not again reach its former proportions. Of the remaining countries with which there has been any significant trade with the United Kingdom in raw cocoa, Switzerland, Sweden and Italy appear to offer the best prospects of development.

NOTES

The Trade and Agriculture of the Gold Coast.—The following account of recent developments in the trade and agriculture of the Gold Coast is taken from a message addressed by Sir Hugh Clifford, K.C.M.G., Governor of the Gold Coast, to the Legislative Council when presenting the estimates of revenue and expenditure for the year 1919:

The Present Trade of the Gold Coast

" A period such as that which I am now reviewing, more than two-thirds of which have been passed under the shadow of the greatest and most devastating war ever recorded in human history, cannot be judged by ordinary criteria. In normal times the material prosperity of

this Colony may be more or less accurately gauged by the quantity and value of its commercial imports and exports. To-day, however, these statistics afford a somewhat less secure guide. The war has caused an extraordinary inflation of the prices of all imported goods, and this has been reflected in an increased cost of all articles produced for local consumption, including native food-stuffs. On the other hand, the local prices offered for articles of export, and especially for cocoa, have proportionately decreased since the outbreak of war, and the high figures which represent the value of our exports during the years 1915, 1916 and 1917, indicate that very large quantities have been shipped, but that the farmer has received much less money for his crop than was the case before the war. Trade in war-time is attended, of course, with great risks. The charges for freight, insurance, etc., are all abnormally inflated and the merchant is compelled to cover himself as far as possible from any losses which these things may occasion. In this endeavour the numerous firms and private speculators operating in the Gold Coast are believed to have been not altogether unsuccessful; but though, up to the end of 1917, the volume of our export trade had greatly increased, the actual producer of the articles exported, while subjected to increased taxation, has received only a modest share of the profits yielded by the industry in which he is engaged. None the less, an examination of the following figures will be found to be highly instructive:

Year.	Commercial imports.	Commercial exports.	Total trade.
	£	£	£
1912	3,140,786	4,004,294	7,145,080
1913	3,250,673	5,023,646	8,274,319
1914	3,158,171	4,469,753	7,627,924
1915	3,116,686	5,814,810	8,931,496
1916	4,881,920	5,576,134	10,458,054
1917	2,964,453	5,529,068	8,493,521
January 1st to August 31st, 1918	1,818,817	2,554,818	4,373,635

"From the above it will be seen that the immediate effect of the outbreak of war was to administer a sharp set-back to the trade of the Colony. How sharp that set-back was may be judged from the fact that, up to the end of July 1914, the average monthly value of our commercial trade for that year had exceeded £737,000, whereas from the 1st August to the end of the following December, that average fell to £493,367—a drop of nearly a quarter of a million sterling per mensem.

" During the decade immediately preceding the commencement of hostilities, our commercial relations with Germany had gradually but steadily expanded ; and in 1913 our imports from that country were valued at £386,670, and our exports to her at £899,468. At that time these figures represented 11 per cent. and 17 per cent. respectively of the Colony's total import and export trade. From August 1914, imports from Germany automatically ceased ; and though our cocoa continued till late in 1916 to find its way thither through neutral ports, the elimination of Germany from our import trade and the barriers which separated our produce from her markets caused a considerable amount of dislocation in the Colony's commercial affairs.

" The recovery, however, was unexpectedly rapid ; and though in 1915 the value of our commercial imports fell some £41,000 (from £3,158,171 to £3,116,686), the value of our commercial exports showed an increase of £791,164 over the figures recorded during 1913—the last complete year before the outbreak of war—which until then had been the highest ever recorded. Thus the total value of our trade (exclusive of Government transactions and specie) during 1915 exceeded all previous records by more than £657,000.

" This, during the second year of the war, was a sufficiently remarkable achievement. The figures for 1916, however, are still more favourable, for, though the drop in the price of cocoa towards the end of that year caused the value of our commercial exports to fall short of that for 1915 by £238,676, the value of our commercial imports rose from £3,116,686 in 1915 to £4,881,920 in 1916, an increase of £1,765,234, swelling the total value of our trade for that year (exclusive of Government transactions and specie) to the unprecedentedly high figure of £10,458,054, which exceeded that for 1915 by £1,526,558, and that for 1913—the last year before the outbreak of war—by £2,183,735.

" Until the closing months of 1916, therefore, though the enhanced value of imports was in part attributable to the steadily increasing prices of all commodities, not only had the trade of the Colony recovered very quickly from the set-back which it had received in 1914, but its expansion was the result of a steady growth, and we were annually paying by our exports for all the articles we were importing and consuming, while each year carrying substantial balances to our credit. These amounted to £1,300,000 in 1914, to £2,698,000 in 1915, and to £695,000 in 1916.

"This state of things was mainly due to the great expansion of commerce between this Colony and the United States of America which has been the outstanding feature of our trade-relations since the commencement of the war. The following table shows the growth of our trade with the United States:

	Commercial imports from the U.S.A.	Commercial exports to the U.S.A.	Total.
	£	£	£
1913 . . .	251,742	101,055	352,797
1914 . . .	270,176	93,383	363,559
1915 . . .	349,106	329,466	678,572
1916 . . .	751,225	603,772	1,354,997
1917 . . .	723,182	1,005,204	1,728,386

"During the five years ending the 31st December, 1917, therefore, the value of our trade with the United States of America very nearly multiplied itself by five. In part this increase is apparent rather than actual, as before the war considerable quantities of hardware, machinery, tools, food-stuffs, rum, lampware, lumber, etc., of American origin reached us through the British market, and therefore appeared in our returns as British goods. Such goods have come to us from the United States direct since 1915, and are now shown in our returns as American goods. Similarly, before the war, some of our lumber, cocoa, etc., was imported into the United States via the United Kingdom. Of late years we have shipped our produce straight to America. When full allowance has been made for these facts, however, the expansion of our trade with the United States since the outbreak of war will be found to have been sufficiently remarkable. This is undoubtedly to be regarded as a direct effect of the war, and when normal conditions are restored it is to be anticipated that a great deal of this trade will drift away from us, much as it has drifted to us during this period of commercial dislocation. It may reasonably be hoped, however, that a portion of it will be permanently secured to us, and that the Colony will be the richer through the possession of an important customer whose transactions with us during the years preceding the war, though showing signs of growth, were conducted on a comparatively small scale.

"During the years 1915 and 1916, therefore, the trade of the Gold Coast had not only recovered the ground lost during the closing months of 1914, but had expanded in a manner which no one would have been bold enough to predict at the commencement of hostilities. It had

not prospered as it would surely have done during the period under review if normal conditions had continued to prevail, nor had the farmer received so large a share of the profits as usual, but the Colony had improved its commercial position to an extent which, having regard to the circumstances of the time, can only be described as remarkable. It is indeed melancholy to reflect how wonderful might have been the progress made and the local prosperity enjoyed during these years if no untoward event had occurred to stay our advance; but, on the other hand, the Gold Coast has much reason to be thankful that in the midst of such a world-wide upheaval it was able, during the first three years of the war, not only to maintain its footing in the commercial world, but very considerably to progress.

"It would have been too much to expect that so fortunate a state of things could indefinitely endure. During the closing months of 1916 the blockade of Germany was drawn tighter by His Majesty's Government, and any cocoa which had hitherto been allowed to find its way into that country through neutral ports was henceforth rigorously shut out. This had forthwith a marked effect upon the cocoa markets of Europe, which threatened to find themselves overstocked.

"Early in 1917 the Germans began their intensive submarine campaign, and His Majesty's Government found it necessary to limit the importation of certain articles, in order that shipping-space should be made available for others which were more urgently needed by consumers in Great Britain, and for munitions and other public purposes. Cocoa was one of the first articles the importation of which into the United Kingdom was restricted from the outset, and the announcement of this policy was immediately followed by the fall of local prices for cocoa to figures for the lowness of which no precedent existed. The American market, however, was found to offer considerable opportunities for speculators, with the result that the ranks of cocoa-shippers received many accretions, and the quantity purchased from the farmers exceeded all previous records. The shortage of shipping also caused a heavy fall in the value and volume of our commercial imports; and thus in 1917 we find it reduced to £2,964,453, which is the lowest figure recorded since 1911, and is all the more striking having regard to the high prices ruling for all imported commodities.

"Owing to the large shipments of cocoa to the United States of America, the value of our commercial exports during 1917 still stood at the respectable figure of

£5,529,068, which, though it fell short of the value of our exports during 1915 and 1916 by £285,742 and £47,066 respectively, still exceeded that for 1913—the year immediately preceding the outbreak of the war—by rather more than half a million sterling.

"The value of our exports, it should be remembered, is calculated not with regard to the market-prices ruling in Europe or America, but upon local prices and expenses computed at the port of shipment. In this connection the following table, which shows the actual quantities of cocoa exported annually from 1912 to 1917, will be found to be instructive:

Year.	Cocoa exported.	Value.
	Tons.	£
1912	38,646	1,642,733
1913	50,553	2,489,218
1914	52,888	2,193,749
1915	77,278	3,651,341
1916	72,161	3,847,720
1917	90,964	3,146,851

"From this it will be seen that the Colony's exports of cocoa have steadily increased in spite of the war, but that the locally calculated value in 1916, when only 72,161 tons of cocoa were shipped, exceeded that of the 77,278 tons exported in 1915 by £196,379, and the value of the 90,964 tons shipped in 1917 by £700,869. This indicates, of course, that while fair prices were offered for cocoa in the markets of the Gold Coast during 1915, and good prices during the greater part of 1916, those ruling during 1917 were very depressed and discouraging. The average price of cocoa at the port of shipment—including purchase price, transport, bagging and all local expenses—was £45 19*s.* 1*d.* per ton (say 25*s.* 4*d.* per load) in 1915, £53 6*s.* 5*d.* per ton (say 28*s.* 7*d.* per load) in 1916, and £34 11*s.* 10*d.* per ton (say 18*s.* 6*d.* per load) in 1917. Of these sums it is difficult to say what proportion has actually found its way into the hands of the cocoa farmers, but the prices which have ruled during the greater part of 1917 and during the current year would seem to show that it never exceeds 50 per cent. of the value locally computed at the port of shipment, and of late has fallen considerably below that figure.

"The real period of stress, however, did not begin until near the commencement of the current year. In 1917, as has been seen, our exports of cocoa exceeded all previous records by more than 13,600 tons, and surpassed the shipments of 1913 by more than 40,400 tons. Of the

total quantity of 90,964 tons, 40,552 went to the United Kingdom, nearly 21,000 were taken by France, and just over 29,000 went to the United States of America. I have already referred to the causes which since the closing months of last year, and especially during 1918, have occasioned, not only a shortage of shipping, but a material restriction of the space available for cocoa on the vessels still plying up and down the coast. The war has not materially interfered with the actual capacity of this Colony either as a producer or as a consumer; but, so long as we are unable to ship our cocoa, the sources of local income, both public and private, are more or less effectually dammed up. This is what has now occurred, and from January 1 to August 31, 1918, the total value of our commercial exports amounted to £2,554,818, and that of our commercial imports to £1,818,817, a total for the first two-thirds of the year amounting to only £4,373,635. If that average be maintained to the end of next December the total value of our commerce for the current year, exclusive of specie and Government transactions, will not greatly exceed £6,500,000. This sum falls short by more than a million sterling of the lowest figure touched since 1912.

Agriculture

"Although recent discoveries point to the possession by the Gold Coast of much mineral wealth, of which only a very small portion has hitherto attracted attention, and though it is probable that the future of the Northern Territories lies in the potentialities of that Dependency as a cattle-producing country, in the Colony and Ashanti agriculture is, and will always continue to be, the principal source of local prosperity. It is by the export of agricultural produce that the Gold Coast annually pays for the great bulk of our imports, and until quite recently the balance of exchange has been predominantly in our favour.

"The agricultural position of the Gold Coast is, in a way, unique. Until the last fifteen years of the nineteenth century permanent cultivation was, to all intents and purposes, an unknown art to the vast majority of the native population. In many parts of the country the people had been accustomed, from time immemorial, to exploit their self-sown palm groves, to utilise for their own consumption the oil and the 'wine' which the trees produced, and, since the advent of Europeans, to dispose of their surplus stocks of oil and to collect and prepare

palm-kernels for the market as articles of regular trade. Similarly, in other districts, rubber had been worked upon a considerable scale; and in others, where kola-trees abound, the nuts were gathered and sold to native traders for transport into the interior or to other parts of the West African Coast. The work demanded of the natives in these connections, however, entailed nothing in the nature of tillage; and, for the rest, the raising of annual food-crops in temporary clearings, by the aid of very primitive methods, represented the only form of agriculture which circumstances had made it necessary for them to develop.

"*Cocoa.*—The introduction of the cocoa-tree effected a sudden and radical change in the life and habits of the agricultural population of the Gold Coast; and it is well, I think, to realise how steep an ascent in the cultural development of a people is entailed by their adoption of permanent cultivation, when the previous experience of their race has been confined to the care of purely temporary food-plots. In its way, it is a revolution as great as that which in ancient times was effected by the substitution of the neolith for the palæolith, or of iron for bronze; and if the mastery which the natives of the Gold Coast have so far attained over the new methods be imperfect and defective, it should be remembered that their conversion to permanent agriculture is not the result of a gradual and natural process of development, but instead is the work of little more than three decades. In these circumstances wonder, I think, should be awakened, not by the failure of the people as a whole readily to adopt a high standard of cultivation in their cocoa-farms, but by the alacrity which they have shown to embark upon an enterpise of a kind wholly foreign to their experience, and for which their previous history had in no way prepared them. How quick they have been to avail themselves of the opportunity, thus tardily placed within their reach, is best illustrated, I think, by the following figures:

Exports of Cocoa

Year.	Quantity exported.
1891	80 lb.
1901	960 tons
1911	35,261 ,,
1913	50,554 ,,
1917	90,964 ,,

"At the present moment, it is probable, the total annual crop of cocoa produced by the natives of the

Gold Coast and Ashanti does not fall far short of 120,000 tons, and it may be taken as representing approximately half the total annual production of cocoa for the whole world.

"When it is remembered that this industry has been throughout, almost exclusively, in native hands and under native management, and that these remarkable results have been achieved by a people who have for the first time embarked upon an agricultural enterprise of a permanent character, the rapid expansion of cocoa-growing in the Gold Coast will be found to be a phenomenon to which it would be difficult to find any parallel elsewhere in the tropics. It is at once fortunate and unfortunate that the introduction of the natives of the Gold Coast to the mysteries of permanent cultivation should have been made through cocoa, which is perhaps the least exacting of any crop that falls within this category. It is fortunate, because the spread of the cocoa industry has not interfered with the production by the natives of the necessary vegetable food-supplies, upon which the whole country is dependent, and yet has shown the people what advantages are to be gained from the possession of permanent, as opposed to mere temporary and shifting plantations. This lesson is one which will never be completely forgotten, and for the future, I think, the people will never again be content to put their land exclusively to the slender use and to obtain from it the poor returns which satisfied their ancestors. On the other hand, the hardiness of the variety of cocoa which is grown in the Gold Coast, and the manner in which it often succeeds in defying even the most gross neglect, have caused the natives to regard permanent cultivation as a far easier task than it really is, and have encouraged them to rest content with comparatively poor results, when a moderate amount of sustained labour and attention devoted to their cocoa gardens would vastly improve both the volume and the quality of the crop. The time has arrived, however, when the rapid growth of the industry threatens the Gold Coast with the dangers inseparable from over-production, and the more enlightened of the chiefs and cultivators, especially in the Eastern Province, are awakening to the necessity for improved agricultural methods.

"At no very distant date, I anticipate, the local markets will be definitely closed against all cocoa of an inferior quality, for the volume of the annual crop is likely to become so great that purchasers will be able to exercise a wide range of choice.

"To the vicissitudes of fortune, which the cocoa farmers in the Gold Coast and Ashanti have of late years experienced, I have already had occasion to refer; and in present circumstances I have not regarded the moment as opportune for any organised attempt to be made to bring pressure to bear upon them with the object of inducing them to produce cocoa of a better quality, and, to that end, to pay more attention to the cultivation of their gardens. For the sake of the reputation of the Colony's staple article of export, which of late has fallen very low in certain quarters, it is, however, obvious that action of some kind must soon be taken in the public interest. It has not been found possible, unfortunately, to come to any arrangement with the merchants—most of whose purchases of cocoa are made for them by native brokers—to reject inferior cocoa when offered for sale, or to ensure a better price being paid for beans which have been well prepared for the market. One or two firms, it is true, of which Messrs. Cadbury Brothers and Messrs. Pickering and Berthoud are the principal examples, have consistently refused to buy cocoa which is not of approved quality, and the adoption of this policy has been productive of good results. Speaking generally, however, cocoa of almost any kind still finds a market, and the industrious farmer seldom secures a price which is appreciably better than that which is obtained by his most indolent neighbour.

"The remedy would seem to lie in the inspection of cocoa at the ports of shipment, and the prohibition under a severe penalty of the export of any consignment which fails to attain to a certain standard of quality. At the present moment unusually large stocks of cocoa are stored in the Colony, and the prospects of the farmer with regard to the disposal of the 1918–19 crop are gloomy in the extreme. When the existing stringency in the shipping world is once more relaxed, however, the exports of cocoa from the Gold Coast are likely to be resumed in greater volume than ever. When this occurs, the time will, I think, be ripe for the adoption of action of the kind above suggested.

"During the current year an experiment has been tried by me the object of which was to see how far it was possible for better prices to be secured to the cocoa-farmers by affording them an opportunity of shipping their crop direct to the overseas markets. This was rendered possible when the licences to export cocoa to the United Kingdom, which had been granted by Government to the Basel Mission Trading Factory and the Anglo-Belgian

Stores, fell in, owing to these institutions being closed. The licences in question covered an aggregate of 2,284 tons of cocoa, to which the Board of Trade added 2,284 tons more; and I decided to allocate these licences among certain of the Paramount Chiefs of the Eastern Province in trust for the cocoa-farmers of their divisions, who are among the largest cocoa-producers in the Colony. A similar allocation was also made to certain chiefs in Ashanti, under the immediate supervision of the Chief Commissioner. The licences were in no sense given to the chiefs themselves, but were held by them in trust for their people; and it was carefully explained to them by me that the possession of a licence did not in any way carry with it a guarantee that shipping-space would be available for the export of the quantity named therein, and that the licence-holders would occupy in the matter of the allocation of shipping-space precisely the same position as that which the firms, from whom the licences had been inherited, would themselves have held. This means, of course, that whenever space was available the chief holding a licence would be entitled to his share in common with other licence-holders, the amount of space being allocated on each occasion in proportion to the total quantity which each licence-holder was entitled to ship by virtue of the terms of his licence. No injury of any kind was thus done to the other licence-holders, as, had the Basel Mission Factory been allowed to continue its operations, it would have enjoyed, as against them, precisely the same privileges in this matter as those which were now transferred to the farmers through their chiefs.

"No allocation of licences was made in the Central Province, partly because the quantities which the Basel Mission were entitled under their licences to ship from Saltpond, Winnebah and Appam, if divided among all the tribal divisions in the Central Province, would have represented a negligible quantity for each; partly because the factory held no licences to ship any cocoa from Cape Coast, the principal port of the Central Province, and its exclusion from the privilege enjoyed by other Central Province ports would have occasioned much discontent; partly because the supply of shipping visiting the ports of Winnebah, Saltpond and Appam is already so small that the granting of licences to ship when so little space was available would only have raised hopes foredoomed to disappointment; partly because no railway facilities exist in the Central Province, and the Tribal Authorities would have at their disposal no efficient means of transporting their cocoa to the ports on their own account;

and partly because, so far as the Colony was concerned, I desired as far as possible to keep this experiment under the direct supervision of the central Administration.

"Railway facilities being available to transport Ashanti cocoa to Sekondi, and the Chief Commissioner being in a position closely to supervise the experiment, licences to export 800 tons of cocoa to the United Kingdom were placed at his disposal for the relief of the cocoa-growers of the Protectorate.

"The action taken by me in this matter has, not unnaturally, aroused a good deal of opposition among the mercantile firms, and a deputation of the Chambers of Commerce of London and Liverpool recently waited upon the Under-Secretary of State to protest against it. The main allegation of the Deputation, which was to the effect that special privileges in the matter of the allocation of shipping-space were being granted through the chiefs to the farmers, is without foundation in fact, and must have been based upon some misunderstanding, the origin of which I have not been able to trace. For the rest, the Deputation's claim that the licences granted to the Basel Mission Factory, when they reverted to Government, should have been distributed proportionately among the remaining licence-holders, is supported by no argument, and does not appear to me to rest upon any sound base of ethics or justice. Such action, if taken, would have increased the share of shipping-space which the largest firms are at present entitled to claim, but would have left all other shippers, and, above all, the producers of the cocoa, *in statu quo*. No one realises more fully than I do that the purchase of cocoa during the past eighteen months has inevitably been a highly speculative venture, and in these circumstances no one can justly blame the purchasers of the crop for buying it at depressed prices which would leave a wide margin of protection against possible loss. So far as my information goes, however, it was the cocoa-farmer, much more than the cocoa-buyer, who in March last, when the allocation of the Basel Mission Licences was made by me, stood in most urgent need of relief, and this the action taken was designed to afford them.

"As regards the results of the experiment in question I am not yet in a position finally to speak. I believe it to have been very successful in Akim Abuakwa. I hope that it may, in the end, prove equally so in Akwapim. With regard to the Ga Division, I am considerably less sanguine.

"*Palm-oil and Kernels.*—The quantity of palm-oil

and palm kernels annually exported from the Gold Coast from 1912 to 1917 is as follows :

Exports of Palm-oil and Kernels

Year.	Oil. *Gallons.*	Kernels. *Tons.*
1912	1,444,432	14,628
1913	860,155	9,744
1914	495,763	5,633
1915	330,990	4,064
1916	450,360	5,857
1917	198,900	4,768

"These figures illustrate the steady decline of the palm industry in the Gold Coast, which has synchronised with the growth of the cocoa industry, and which even the depressed prices locally ruling for the latter product have failed to revive. The far less exacting labour which the cultivation of cocoa, as generally carried on in the Gold Coast, entails upon the farmer, disinclines him to return to the much harder work of preparing kernels and palm-oil for the market. The money won from cocoa during the past ten years, moreover, is probably not yet exhausted ; and it cannot be hoped, I think, that the palm industry will revive, save possibly under the stress of really acute financial embarrassment. At the present time, though special shipping facilities are accorded to exporters of palm-oil and kernels, which products are in great demand for the manufacture of munitions and for other purposes in the United Kingdom, the prices locally ruling do not greatly tempt the natives to engage once more in an industry which they of late years have very generally abandoned.

"Much discussion has recently taken place as to the best oil and kernel producing varieties of the West African palm-trees, the effects produced by cross-fertilisation and other similar questions ; and it has been suggested that good results might be obtained by the adoption of what practically amount to plantation methods of the modern European type. So far as the Gold Coast is concerned, and having regard to the high cost of labour in this Colony, I cannot think that any such experiment is likely to prove financially profitable.

"During the past few years two British companies, which have established themselves in the Western Province, have erected expensive and up-to-date machinery for the treatment of palm-oil and kernels, and have laid down systems of tram-lines designed to keep the factories fully and regularly supplied with the necessary material.

I have not had an opportunity of personally visiting either of these works, but I am informed that the operations of both companies promise to yield good results. Though, as I have said, I cannot think that the cultivation of palms in plantations under European management is likely to prove a profitable enterprise, there is obviously considerable scope for improved methods of treatment, production, transportation and even of cultivation on the lines now being followed in the Western Province.

"*Rubber.*—The following table shows the annual export of rubber from 1912 to 1917 inclusive:

Exports of Rubber

Year.	Quantity exported. lb.
1912	1,990,699
1913	1,317,369
1914	654,133
1915	647,982
1916	2,215,973
1917	2,961,204

"It will be observed that the past two years have witnessed a quite remarkable revival of the rubber industry, which in 1914 and 1915 appeared to be almost moribund. This is mainly due to the increased demand which the war has occasioned, but in part also to the improved output of certain Para rubber plantations in the Western Province. One of these, situated at Dunkwa, has been managed with great skill and intelligence, and is already producing satisfactory results. It remains to be seen, however, whether, when normal times return, the cultivation of plantation rubber in the Gold Coast will be able successfully to compete with the skilled and cheap labour at the disposal of European planters in Malaya, Java and Ceylon.

"*Kola.*—The following table shows the quantity of kola-nuts annually exported from the Gold Coast for the years 1912 to 1917 inclusive:

Exports of Kola

Year.	Quantity exported. lb.
1912	7,134,161
1913	7,037,976
1914	7,877,813
1915	8,280,596
1916	6,789,815
1917	11,984,645

"With the exception of a certain limited quantity

produced upon an European plantation in the Eastern Province, all the kola grown in the Colony and in Ashanti is in native hands. The figures above quoted, it should be observed, are only approximate, as the export of kola from Ashanti, which is carried on by caravans from the north, is estimated, but is not subject to any exact check. The bulk of the cocoa exported, however, passes through the ports of the Colony, and during the last two years the depression in the cocoa-market has caused the natives, especially in the Saltpond District of the Central Province, to pay renewed attention to their kola-trees."

The Sandalwood of Western Australia.—The following note on the sandalwood of Western Australia has been sent by Mr. C. E. Lane-Poole, Conservator of Forests in Western Australia, with a request that it may be published in this BULLETIN. The question of the composition of the oil derived from this sandalwood is now under investigation at the Imperial Institute.

"The Note in the January–March issue (vol. xv., No. 1) of the BULLETIN dealing with the production of sandalwood oil in Mysore is both informative and interesting, but its references to Western Australian sandalwood hardly do justice to that product, and contain some assumptions which have no foundations in fact. The 'so-called sandalwood exported from Australia' (to quote the Note) 'is mainly derived from *Fusanus spicatus*, R. Br., a tree attaining about 30 ft. in height, native to Western Australia, whence the bulk of the export is derived.' Baron Ferdinand Von Mueller, who is universally accepted as authoritative when dealing with Australian flora, says of the Western Australian tree, '*Santalum cygnorum* (Miquel), South-Western Australia, where this small tree furnishes scented sandal-wood. The wood on distillation yields nearly 2 per cent. of oil.' It would seem that some confusion in nomenclature exists in regard to *Santalum* and *Fusanus*, but it is equally obvious that the two names do not in this instance indicate differences in genera but are merely synonyms. Dr. F. L. Stoward, Government Botanist and Plant Pathologist of this State, supplies the following memorandum which appears to cover the whole ground and to dispel once and for all the delusion that Indian and Western Australian trees belong to families specifically different. Dr. Stoward says:

"'In response to your enquiry regarding the sandalwood tree of Western Australia (*Fusanus spicatus*, R. Br.) and its synonym: this name is recorded in the *Index Kewensis* as a synonym of *Santalum cygnorum*, Miq.

" 'The Western Australian Sandalwood-tree is also described in Mueller's census under the name of *Santalum cygnorum*.

" 'Another synonym also appearing in the *Index Kewensis* is *Santalum spicatus*, A. DC.

" 'The position is that the genus *Fusanus* maintained by Robert Brown was later united with the genus *Santalum* by De Candolle.

" 'In short, it will be seen that whether *Fusanus* is united with the genus *Santalum* or is maintained as a distinct genus depends upon whether we agree to adhere to De Candolle's or Robert Brown's classification of these genera. The decision rests almost entirely with the systematic botanist, and depends in part on very slight differences of the floral parts in the two genera, and on the relative value which any two systematists would attach to these small differences. In short, the genus *Fusanus* approaches so closely the genus *Santalum* that, if finely drawn distinctions are waived, it may be regarded as identical with it.

" 'Systematic classification rarely has any reference to or any bearing on the economic products derivable from any given plant species. The Western Australian Sandalwood-tree (*Fusanus spicatus*, R. Br. = *Santalum cygnorum*, Miq.), I understand, yields a sandalwood oil which is practically identical, chemically and pharmacologically, with that obtained from sandalwoods from other sources of supply. It seems fantastic in the extreme to contend that the oil from the Western Australian sandalwood is not identical with or is inferior to that from other sources of supply because the plant has been casually referred to as a species of *Fusanus* rather than as a species of *Santalum*. As has been shown, the plant may be equally regarded either as a *Fusanus* or as a *Santalum*, and whichever synonym is adopted is merely a matter of adherence to one or other of the eminent botanists who first dealt systematically with this particular group of plants.'

" It would be a matter of no difficulty, arguing along the line taken by the writer of the Note in the BULLETIN, to impugn the correctness of the classification of the Indian tree as *Santalum album*, and a rabid partisan might even stigmatise it as 'so-called sandalwood' and the oil derived from it might, with the easy assurance of prejudice or the ready confidence of inexact knowledge, be labelled 'substitute.'

" Discussion as to verbal differences in botanical classification of Western Australian sandalwood reaches

satisfactory finality when the oil obtained from the tree comes under notice. Many years ago, when sandalwood was fairly plentiful in those areas of Western Australia now occupied almost exclusively by agriculturists, sandalwood oil was manufactured. But for various reasons the trade was never developed. Of recent years a start has again been made, and an oil produced which has found a ready sale. The santalol content of the Western Australian oil varies from 75 to 80 per cent., but the oil has not yet been officially recognised by the British and American pharmacopœias because there has hitherto been present in it a certain small percentage of sesquiterpene ethyl. Therapeutically the presence of this foreign element has formed no bar to its success. The oil has been and is used in the Public Hospital at Perth and in other hospitals in Australia, and there is evidence that the sesquiterpene ethyl is as actively curative as the santalol in the oil. But its presence was held to place the oil below the standard demanded by the pharmacopœias. The manufacturer here, having found ready sale for his product at fair prices, did not at the outset attach much importance to the foreign element in his oil. But the increased demand arising through the war induced him to make efforts to bring his product up to British pharmacopœia requirements. With this view he submitted it to a chemist of repute in London, and has, within the last few months, learned that a process has been found which entirely eliminates the sesquiterpene ethyl, thus at once placing the Western Australian product on a par with Mysore oil and meeting the B.P. standard.

"The figures given in the Note as to the value of the sandalwood exported from Western Australia, prove that the wood finds ready markets, but whether the whole of the export is used in perfumery, carving and for ceremonial purposes, or is used in part for the production of 'Indian' oil it is impossible to say. In view of the decision of the Mysore Government to increase its output of sandalwood oil and in the end, as it would appear, to establish a virtual monopoly in Mysore oil, a demand for Western Australian sandalwood is likely to arise in Europe after the war. Sandalwood is getting scarce in and near the settled districts of Western Australia, but the extent to which it still exists is not accurately known. The present supplies are largely drawn from the Eastern Goldfields areas, but it is understood that sandalwood has been found in mid-continent in the neighbourhood traversed by the Trans-Australian railway. The extent of the growth there has yet to be ascertained."

Agriculture in Cyprus. — In his *Annual Report* for 1917–18 the Director of Agriculture, Cyprus, states that in consequence of the war the value of the work of the department is being increasingly recognised in the island. Improved methods of cultivation are being introduced, including the use of modern labour-saving agricultural machinery. New fodder crops have been tried and the tobacco industry has been greatly extended. A considerable area of land in the Larnaca District has been reclaimed and used for the production of tobacco and cotton. Under the control of the Department 21 new orchards and 21 new vineyards have been started; owing to the increased demand for Cyprus wine in Egypt 6,777 donums (2,239 acres) of new vineyards were established in 1915–16 and improved methods of vine-cultivation instituted. Flowers of sulphur are now being made in the island from local material, for use as a fungicide in the vineyards.

Although the production of olive-oil during the year was only moderate, the cultivation of the olive-tree is extending. Shinia oil has been experimentally produced from the berries of *Pistachio lentiscus* and has been used for edible purposes and for soap-making. A sample of the oil has been examined at the Imperial Institute.

The war with Bulgaria has led to a considerable development in rose cultivation in Cyprus, and an experimental distillation of otto of rose was carried out at Milikouri. In addition to the distillation of Origanum oil as in former years, essential oils of thyme, sage and wild lavender have also been produced.

The damage caused by the Mediterranean fruit-fly (*Ceratitis capitata*), vine sirividhi, carob disease, and the codlin moth has been greatly diminished. The last named has proved very difficult to eradicate, as the only successful method appears to be the daily collection and destruction of affected fruits. The active campaign carried out by the Department for the prevention of plant disease is meeting with considerable success, although somewhat handicapped by lack of staff.

Efforts to establish an improved breed of silk-worms in Cyprus are proving successful, cocoons of better and more uniform size are being produced while the quality of the spun silk is satisfactory.

Production of Cinchona in Madras and Bengal.—In an article entitled, "The Future of the Trade in Cinchona Bark," published in this BULLETIN (1918, **16**, 370), particulars were given of the production of cinchona on

Government plantations and the output of quinine in Madras and Bengal. The following additional information is taken from the recently issued *Reports* on the Cinchona Departments of these Provinces for the year 1917–18.

Madras.—The exhaustion of the supplies of bark both on Government and private plantations in Madras is causing some apprehension and is engaging the attention of the Cinchona Department. The total area under cultivation on the Government plantations was 1,684 acres at the beginning of the year, of which 1,007 acres were planted with cinchona trees. During the year a further area of 235 acres was planted with cinchona, whilst 54 acres were uprooted, so that the total area under cinchona at the close of the year amounted to 1,188 acres. Large numbers of plants of *C. ledgeriana* are being raised in the nurseries and in those of the Hooker division alone there were 800,000 plants of this variety, and in addition 600,000 plants of cinchona hybrids.

On the Dodabetta plantation 30 acres were planted with *C. officinalis*, and on the Naduvattam plantation 100 acres of *C. robusta* were interplanted with silver oak. On the latter plantation 65 acres of land which had been under silver oak for ten years were prepared for planting with cinchona in 1918–19, and it will be interesting to observe how far the silver oak improves the soil. In the Hooker division 105 acres were planted with cinchona during the year.

At the Quinine Factory at Naduvattam a record was created both as regards the output of quinine sulphate and the proportion of quinine extracted from the bark, the latter amounting to 93 per cent. of the theoretical yield. The total quantity of bark worked up in the factory during the year was 1,284,351 lb., the average quantity of quinine in the bark being equivalent to 4·59 per cent. of quinine sulphate. The Government plantations supplied 87,037 lb. of the bark used, and of the remainder 900,525 lb. were purchased locally and 257,250 lb. consisted of Java "ledger" bark. Altogether 55,014 lb. of quinine sulphate was produced during the year as compared with 52,513 lb. in 1916–17.

The increased production of quinine at the Madras factory during the past two years has been accomplished without addition to the existing plant, as the new machinery, under order for a considerable time, has not yet been installed. A scheme for providing the factory with hydro-electric power is under consideration.

Bengal.—The cinchona trees on the two Government

plantations in Bengal, situated respectively at Munsong and Mungpoo, are not yet in full bearing. Of 2,060 acres planted with cinchona at the former plantation at the close of the year 1917–18, 1,787 acres were occupied with trees less than six years old, and at Mungpoo the corresponding figures were 454 and 338. The chief variety grown at both localities is *C. ledgeriana*, which occupies a total area of 1,626 acres. The cultural conditions of the plantations are satisfactory, but it will be two or three years before they can produce sufficient bark to supply fully the needs of the factory.

The area under cinchona at both plantations was extended during the year, 262 acres being planted at Munsong, of which 205 acres were planted with *C. ledgeriana*, and 53 acres were planted with this variety at Mungpoo. At the former plantation the trees on 149½ acres were stripped, yielding 422,487 lb. of bark, of which 382,591 lb. was "ledger" bark, whilst 196,216 lb. of "ledger" bark were collected from 57 acres at Mungpoo. The average amount of quinine in the "ledger" bark from Mungsong was equivalent to 4·77 per cent. of quinine sulphate and from Mungpoo 4·93 per cent.

The quantity of bark used in the Bengal factory during 1917–18 was 654,093 lb., 430,066 lb. being derived from the Munsong plantation and 224,027 lb. from Mungpoo, and 29,417·5 lb. of quinine sulphate were produced, as compared with 20,903 lb. in 1916–17. The Department has so far been able to meet the great demand for quinine, over 192,000 lb. of quinine salts having been issued during the three years ending March 31, 1918; but the reserve, which amounted to 165,000 lb. at the close of the year 1915–16, was reduced to 63,248 lb. at the end of the period under review.

RECENT PROGRESS IN AGRICULTURE AND THE DEVELOPMENT OF NATURAL RESOURCES

In this section of the Bulletin *a summary is given of the contents of the more important papers and reports received during the preceding quarter, in so far as these relate to tropical agriculture and the utilisation of the natural resources of the Colonies, India and the Tropics generally. It must be understood that the Imperial Institute accepts no responsibility for the opinions expressed in the papers and reports summarised.*

AGRICULTURE

Foodstuffs and Fodders

Beet Sugar.—A useful contribution to the literature of beet-sugar production has recently been published as *Bulletin* No. 721, 1918, *U.S. Dept. Agric.*, entitled "The Beet-sugar Industry of the United States," by C. O. Townsend, Pathologist in Charge, Office of Sugar-plant Investigations. After giving an account of the number, capacity and location of the beet-sugar mills in the United States, the author describes the soil, sub-soil and topographical conditions necessary for the successful cultivation of sugar beets. Particulars are furnished with regard to the quality of seed for sowing, the methods of cultivation, the requirements in respect of rainfall and irrigation, drainage and seepage. Information is also supplied on the subjects of manuring, the rotation of crops, the necessary farm equipment, and the labour problems involved. Other matters dealt with include the insect pests and diseases of the sugar beet, the maintenance of live-stock on the farm, the by-products of the industry and the marketing of the beets. The bulletin is well illustrated, and a list of other publications of the United States Department of Agriculture relating to sugar and beet-sugar production is appended.

Cane Sugar.—An account of the sugar industry of Mauritius is given in the *Ann. Rep. Dept. Agric., Mauritius,* for 1917. The total production of sugar was about 225,000 tons, of which approximately 90 per cent. was vesou, 5 per cent. syrups, and 5 per cent. low syrups. The proportion of vesou was only 73·80 per cent. in 1911, and its steady increase year by year is an indication of the improvements which have gradually been effected in the manufacture. The quality of the canes produced in 1917 was on the whole satisfactory, those from 31 estates giving an average of sucrose, 13·40 per cent., and fibre, 12·31 per cent. The total area under cultivation was

167,560 arpents (174,765 acres), as compared with 163,409 arpents (170,435 acres) in the previous year, and 43·2 per cent. of this was cultivated by Indians. The number of factories in operation during the year was 55, and the average extraction is estimated as 10·51. An irrigation scheme which has been undertaken in the Black River district was extended during the year and has resulted in 1,400 acres being brought under cultivation which were not previously worked; it is anticipated that the work will be completed in about two years, and will provide sufficient water for 4,000–5,000 acres.

Attention is being given to the introduction of new varieties of cane, as some of the standard varieties at present grown are showing signs of deterioration. It is considered that this deterioration is largely due to the spread of root disease, which has been found to occur in all parts of the island.

The problem of the control of insect pests has been taken up energetically. In the Pamplemousses area, great injury has been inflicted on sugar cane during the last seven years by the Melolonthid beetle, *Phytalus Smithi*. Vigorous efforts have been made to eradicate this pest, and special interest attaches to the attempts to introduce a parasitic wasp, *Tiphia parallela*, from Barbados; an account of this work has been published as *Bulletin* No. 6, 1918, *Scientific Series, Dept. Agric., Mauritius*. It is hoped that the importation of this wasp will eventually lead to a great reduction in the prevalence of *Phytalus Smithi*.

Another insect which has caused a good deal of damage is the "gros moutouc," *Oryctes tarandus*. As related insects in Madagascar are known to be parasitised by a wasp, *Scolia oryctophaga*, steps have been taken to introduce this insect into Mauritius and to demonstrate its value as an enemy of *Oryctes tarandus*. Efforts to establish the wasp in Mauritius are still in progress.

A report on "Sugar and the Sugar-cane in the Gurdaspur District," by J. H. Barnes, B.Sc., F.I.C., has been published as *Bulletin* No. 69, 1918, *Agric. Res. Inst., Pusa*. An account is given of the results of an enquiry which was undertaken primarily with the object of selecting a site for a central refining factory in the Gurdaspur District, this district being regarded as one of the best areas for cane cultivation in the Punjab. The report gives a description of the climate and soil of the district and of the native methods of cane cultivation and sugar manufacture. A large number of analyses are recorded of the different varieties of cane grown, particulars are furnished of the

conditions and volume of the sugar trade in the district, and suggestions are made for the improvement of the industry. The results of the enquiry have led to the conclusion that the erection of a central refining factory could not yet be undertaken with any prospect of its proving a financial success. It is necessary that before this is done the quality of the cane must be improved by the importation of better varieties and the soils must be improved by better methods of cultivation and the application of manures. It is shown that, if sugar refining is to be carried on in the Punjab, an endeavour must be made to produce heavy-yielding canes which will ripen in from 8 to 11 months and will yield a juice of sufficient purity to be easily handled in the factory.

Date Palm Sugar.—A report on "Experiments on the Improvement of the Date Palm Sugar Industry in Bengal," by H. E. Annett, B.Sc., F.I.C., G. B. Pal, M.Sc., and I. B. Chatterjee, L.Ag., has been published in the *Memoirs of the Department of Agriculture in India* (*Chemical Series*, 1918, **5**, 69). It is pointed out that at least 300,000 tons of sugar are produced annually in India from various palms, of which about one-third is produced in Bengal, and that European firms in Madras purchase about 25,000 tons of raw palm sugar per annum for refining and distilling purposes. The annual value of the industry in normal times is estimated at about £2,500,000.

The collection of the juice and the manufacture of the sugar are not carried out at present under good conditions, and the experiments described in the report were therefore undertaken with the object of determining how the conditions might be improved.

It has been found that in the usual methods of collecting the juice a good deal of sugar is lost by inversion during the night after the juice has left the tree. Experiments were made to compare the effect of collecting the juice in (1) earthenware pots, such as are used by the native tappers, but not smoked or treated in any way; (2) earthenware pots, smoked nightly, according to the usual method practised in the date sugar districts; (3) earthenware pots, smeared lightly inside with lime mixed with water to a thick cream; (4) earthenware pots, containing a small quantity of formalin, and (5) metal buckets. It was found that the amount of inversion is considerably reduced by smoking the pots, but that a much better result is obtained by the use of limed pots; the employment of formalin and of metal buckets proved unsatisfactory. As an outcome of these experiments, the authors

recommend that the practice of liming the pots should be introduced into the palm-sugar districts of Bengal, as thereby the gur would be improved both in quality and yield.

In Bengal the juice used for sugar production is collected only at night; that which flows from the cut surface of the tree during the day is so badly fermented that a crystalline solid gur cannot be obtained from it, and is therefore allowed to run to waste. Experiments have been made to ascertain whether the quality of the day juice could be improved, and it has been found that, by using limed pots for collection, fermentation is so much reduced that the juice could be well employed for making gur, and that this would increase the output of gur by about 20 per cent.

It is shown that the quality of the juice is improved if the cut surfaces of the trees are daily washed with water, and it is suggested that the use of dilute formalin might give even better results.

Date palm gur is of a very dark colour, owing to the presence of alkaline constituents in the juice. A light-coloured gur can be obtained by neutralising the juice with an aqueous extract of tamarind fruit or with dilute mineral acid.

Attention was given to the furnaces now used in the manufacture of gur, and it was observed that these waste a large amount of fuel and should be replaced by more economical types.

The native methods of refining palm sugar are very wasteful and slow. Tests made with centrifugal machines have shown that sugar of good quality can be obtained by this means, and it is urged that a thorough trial should be made of centrifugal methods.

The authors recommend that a scheme should be put into operation for producing white sugar or a good grade of raw sugar directly from the juice on a factory scale, and they express the conviction that the wild date palm forms a valuable source for the production of cheap sugar.

Tea.—In the *Ann. Rep. Dept. Agric., Nyasaland,* 1917–18, reference is made to tea planting in that country. The area devoted to the crop in 1917 was 4,523 acres, and the output of manufactured tea amounted to 227 tons 8 cwts. Only a small proportion of the area is in full bearing, but the yield per acre of tea on plantations in full bearing in Mlanje is 250 lb., and a few of the best gardens now give 330 lb. per acre. The industry has received a severe check owing to the restrictions which were placed

on the importation of the tea into the United Kingdom. On account of the increase in cost of tea-chests and other materials used in tea manufacture, it is estimated that the crop cannot now be profitable unless it realises at least 8*d.* per lb. The green leaf is purchased by the factories at 1*d.* per lb., which is equivalent to 4·5*d.* per lb. of dry tea. The cost of manufacture, chests and transport to the railway amounts to 2·625*d.*, bringing the total cost to 7·125*d.*, so that a price of 8*d.* per lb. leaves only a narrow margin for profit, insurance, etc.

Desert Shrubs as Fodder.—During 1916 and 1917 an unusual drought was experienced in the south-west of the United States, from central Texas to the Pacific coast, and in consequence the normal crop of range grass was not produced. As a result of this, attention was directed to the possible utilisation of certain desert plants as a feeding-stuff for stock, and it has been found that several of them are very useful for feeding to cattle and sheep in case of emergency. An account of the utilisation and value of the plants for this purpose is given in *Bulletin* No. 728, 1918, *U.S. Dept. Agric.*, entitled "Certain Desert Plants as Emergency Stock Feed," by E. O. Wooton.

The principal plants referred to in this publication are species of *Yucca*, *Agave*, *Dasylirion* and *Nolina*, and it has been demonstrated by trials on a large scale that several of these, if properly prepared, form a valuable fodder in times of extreme drought. The plants may be chopped by hand, but this is a slow and laborious method, and the result is not nearly so satisfactory as when the chopping or shredding is effected by means of machines which have been specially designed for the purpose and are described by the author. Chemical analyses of these various fodders are recorded, and agree with the experience of the farmers in indicating that the plants are of low nutritive value and comparable with range-grass hay. If fed alone, they are sufficient to keep the animals from starving, whilst if fed in conjunction with concentrated foods a properly balanced ration can be provided. Particulars are given of the best way of feeding the materials and the quantities to be supplied, either alone or with such other feeding-stuffs as cotton-seed cake or meal.

Only two of the species of plants discussed, viz. *Yucca glauca*, the bear grass of the New Mexico-Texas plains, and *Y. elata*, the soap-weed, occurring in the sandy plains of certain regions of Texas, Arizona and New Mexico, may be expected to grow up again after being cut down. The former plant will produce a new crop in three or four

years and the latter would require from ten to fifteen years. It is evident, therefore, that, in order to avoid exhausting the supply of such plants, they should only be employed as a feeding-stuff in times of severe drought and should be allowed to grow during favourable seasons.

The importance of these emergency fodders is shown by the number of animals in the various countries of Texas, Arizona and New Mexico where the plants occur. It is estimated that these amount to 896,812 cattle and 810,540 sheep, and it is pointed out that, if the use of the desert plants in times of drought results in reducing the losses to the normal number, thousands of head of stock will have been saved.

Oils and Oil Seeds

Castor Seed.—The light sandy soil of the Isle of Pines is considered to be very suitable for the growth of castor seed, and it is proposed to attempt the cultivation of this crop on a fair scale (*U.S. Commerce Repts.*, 1918, Aug. 2, No. 180, p. 434). Seed of the Haitian variety has already been supplied for planting, and a contract for 1,500 acres has been made. The seed will be exported to the United States, but if cultivation proves successful the industry may become a permanent one and lead to the establishment of an oil-mill in the island.

Coconuts.—Coconut investigations by the Madras Department of Agriculture have been commenced in the Kasagarod Taluk (*Rep. Coconut Stations in Kasagarod Taluk*, 1918). In order to obtain experiment stations representing the different types of soil on which coconuts are commonly grown on the west coast of Madras, three blocks of land have been acquired, the soils of which are as follows: (1) "laterite" (*i.e.*, fairly heavy loam containing sand or gravel), 15 acres; (2) red sandy loam of great depth, 20 acres; and (3) coarse sandy soil such as is continually formed along the littoral, 20 acres. At present these plots are vacant, but coconut plants have been raised in nurseries from seed from selected trees in Malabar and the preliminary ploughing and digging of holes for planting has been carried out, while analyses of the soil have also been made. In raising plants in nurseries, it has been found that germination is quicker and more uniform in the case of nuts from upland gardens from the interior of Karumbranad and Calikut taluks than those from gardens on red sandy loams near the coast. No differences in percentage or rapidity of germination were noted in

nuts planted (1) by the local method, *i.e.* placing the seed nut vertically with the apex downwards and the base showing above the soil; (2) horizontally; or (3) inclined with apex downwards. It remains to be seen whether the plants produced by these methods will prove equally easy to handle when they have to be planted out. In order to avoid delay, an existing plantation at Kudlu, about 2½ miles from the town of Kasagarod, has also been acquired for experimental purposes.

Experiments on the fertilisation of the flowers and the formation of nuts on individual trees, and an elaborate investigation of the root-system have been commenced. Some observations of insect and other pests have also been made. Rhinoceros beetles cause a certain amount of damage, especially near dwellings. A red ant (*Oecophylla smaragdina*) is found on a few trees, and is troublesome, as it hinders men from climbing the trees and may therefore prevent destruction of beetles. Mites occur in large numbers on branches of the inflorescences after the rains, and may be a cause of infertility. Scale insects do not appear to do much damage except to seedling plants.

The area under coconuts in British North Borneo continued to increase during 1917, though the low price of copra caused many Chinese and natives to turn their attention to rubber (*Ann. Rep. Agric., Brit. N. Borneo*, 1917, p. 6). During 1917, 1,319 acres of new land were planted, the total area under coconuts being 20,139 acres. Sandakan has been for a long time the chief coconut-producing area, but many trees are expected to commence bearing on the East Coast, which should then become the most important area. Although prices of copra at Singapore were low owing to shipping difficulties, about 30,000 cwts. were exported in 1917, compared with about 19,500 cwts. in 1916; over half a million nuts were also shipped. Considerable trouble has been given by the rhinoceros beetle (*Oryctes rhinoceros*) in Province Keppel, where the red weevil (*Rhyncophorus ferrugineus*) is also fairly common; these pests are not common in other districts, and regular inspection should prevent them from increasing. A small leaf-eating beetle (*Brontispa Frogatti*) has been found in all the residencies, but measures of control have been enforced strictly and have kept down this pest.

Wester has contributed a valuable article entitled, "The Coconut, its Culture and Uses," to the *Philippine Agric. Rev.* (1918, **11**, 5). The article deals mainly with coconuts in the Philippine Islands; it covers a wide field and describes the methods of cultivation, the harvesting

of nuts, preparation of copra, and the various insect and other pests, and the means of preventing or combating their attacks. The article is illustrated, chiefly by reproductions from photographs, and will be of interest to coconut planters in all countries.

An American company with a capital of about £10,000 is erecting a factory at Colon (Panama) for the production of coconut and other oils, glycerin, soda, soap, etc. (*U.S. Commerce Repts.*, 1918, Aug. 22, No. 197, p. 709). Supplies of coconuts and other oil seeds will be brought to the factory by the two schooners of the company trading along the coast.

Oil-palm.—An article by Stieltjes (*Institut Colonial de Marseille, Section des Matières grasses*, 1918, No. 6, p. 3) deals fully with machinery for the manufacture of palm-oil and the shelling of palm-nuts. The article is based largely on the information already published in this BULLETIN (1917, **15**, 270), and is illustrated by reproductions from photographs and by diagrams from various patent specifications.

Miscellaneous. — According to Marchand (*S. African Journ. Indust.*, 1918, **1**, 965), the kernels of *Ximenia caffra* are used by the natives as a source of oil. The shell of the nut is easily removed from the kernels, which constitute about 65 per cent. by weight of the nuts and contain 64 per cent. of yellow, viscous, non-drying oil. It was found that the oil could not be prepared from the kernels by cold expression owing to the presence of a sticky substance. It is of interest to note that the oil is very similar in character to that of *Ximenia africana* examined at the Imperial Institute (*cf.* this BULLETIN, 1917, **15**, 313), the kernels of which were found to contain 66 per cent. of oil.

RUBBER

Hevea

Malaya.—The total area of rubber estates over 100 acres in extent in Malaya (*i.e.* the Federated Malay States, Johore, Kelantan, Kedah, Trengganu and the Straits Settlements) in 1917 amounted to 1,908,993 acres, of which 632,929 acres were in bearing (*Agric. Bull., F.M.S.*, 1918, **6**, 402). In addition, 23,417 acres were planted with rubber on holdings less than 100 acres in area. In the Federated Malay States alone, in 1917, the rubber estates occupied 1,044,839 acres; of this area 612,268 acres were planted up with rubber as a pure crop, and on

9,354 acres rubber was interplanted with catch crops, a total of 69,663 acres being planted during the year. The total production of rubber in Malaya in 1917 was 82,319 tons, as compared with 67,677 tons in 1916; the area in bearing amounted to 408,574 acres.

On hilly and undulating estates in the Federated Malay States considerable loss is caused by surface wash of the soil (*Rep. Director Agric., F.M.S.*, 1917, p. 1). To prevent this, catchment pit drains have proved very effective where properly arranged, whilst contour planting of strong grasses, such as citronella, and of cover crops is also employed; terracing is only recommended on new plantations. Results of manurial experiments at Kuala Lumpur showed that manuring generally increased the yield of rubber, but the soil here is distinctly poor. Much attention was given during the year to the thinning out of plantations, and experiments on this subject have been commenced by the Department. On the rubber estates tapping is becoming more and more conservative, and the single cut on one-quarter system is growing in favour.

Bark disease has introduced a new factor into the problem of tapping, and it seems probable that it will prove a very important one, as a long cut increases the danger of infection. Much work on bark diseases has been carried out in the mycological laboratory, as these diseases have occurred throughout the Peninsula with comparative suddenness and to a serious extent. "Black-stripe" has been found to be due to a species of *Phytophthora*, and was as bad on well-kept estates as on overcrowded ones. At first, excision of diseased tissues was recommended, but the application of antiseptics to the tapping cut and to recently tapped bark has given good results, and it is considered that if tapping be stopped the disease will not make headway, except in cases of severe attack. No alarm need be felt if preventive measures are taken immediately the disease occurs.

Mouldy-rot, due to a species of *Sphaeronema*, is practically confined to Negri Sembilan. Overcrowding of trees, poor renewal of bark, and other bad conditions, encourage the spread of this disease, which should be checked, if not eradicated, by better sanitation and preventive painting with antiseptics.

"Brown-bast" is the most serious disease now known in Malaya; it has always been present to a limited extent, but has increased considerably. Although it does not kill trees, it stops the flow of latex and causes burrs which prevent tapping. It is often impossible to detect this

disease until too late to apply effective treatment. An organism thought to be a species of *Spongospora* and to be the cause of this disease was discovered in the diseased tissues, but later work showed the identification to be incorrect, and the cause of the disease is still doubtful.

British North Borneo.—During 1917 about 3,000 additional acres were planted on rubber estates in British North Borneo (*Ann. Rep. Agric., British N. Borneo*, 1917, p. 1). The total area under rubber was 34,828 acres at the end of the year (including an estimated area of 2,695 acres on small native and Chinese holdings). Of this area 21,400 acres were fully or almost fully tapped, representing about one-half the total number of trees. The exports of rubber amounted to 2,444 tons in 1917, compared with 1,938 tons in 1916; the total production in the former year was 2,611 tons. The number of persons working on rubber estates has increased, there being 14,292 coolies employed in 1917, and it is of interest to note that the number of natives of the country employed has more than doubled in two years. Most of the land under rubber is hilly, and the prevention of soil erosion is an important problem. While the rubber trees are young the cultivation of creeping grasses and the encouragement of jungle undergrowth are effective; but as the trees become older and give much shade, catch-trenches will have to be dug unless some cover crop which will grow well in shade can be found. Thinning out is proceeding steadily in most districts. The tapping system still generally adhered to is two cuts on a single quarter.

Although the number of known diseases in British North Borneo has increased, and certain diseases are more prevalent, most of the plantations are comparatively free from diseases. "Pink disease" and "brown-bast" are the only diseases of general occurrence, though considerable damage has been caused on individual estates by attacks of *Sphaerostilbe*, *Ustulina*, "black-thread," and "leaf disease" (*Colletotrichum Ficus*). The methods of remedying the various diseases are discussed in the *Report*, and planters are strongly recommended to destroy all dead stumps and logs which encourage the growth of pests. Burrs formed on tapping surfaces have ruined many trees, but can be prevented by removing all discoloured bark while the burrs are still in a rudimentary stage; so far, trees suffering from burrs have been removed during thinning out, but planters are recommended to familiarise themselves with the method of treatment in future to save loss.

According to the *Rep. Customs Dept., Brit. N. Borneo,* 1917, p. 20, chests for packing rubber have been made from local "white serayah" wood which are said to be equal in quality to the Japanese "Momi" chests commonly used; 2,800 chests were made in 1917, and it is expected that some 10,000 chests will be made in 1918. Serayah wood is stated by Foxworthy (*Bulletin* No. 1, 1916, *Dept. Forestry, Brit. N. Borneo*), to be derived from various species of *Shorea*.

Manuring.—Further results of manurial experiments at Peradeniya are given by Bamber (*Bulletin* No. 36, 1918, *Ceylon Dept. Agric.*). The total yield of rubber from 1914 to 1917, inclusive, was larger from the untreated plot than from any of the manured plots, with the exception of that treated with an excess of phosphoric acid. Both the untreated plot and the plot treated with a mixture of mineral manures showed a decrease in yield in 1917 compared with 1916, while the other plots all showed increased yields. The yield from the plot treated with potash showed only a slight increase, and this plot has given a poor result throughout the experiment. On a basis of cost, phosphoric acid appears to be the most profitable manure, though this plot is inferior in vigour and appearance of foliage to the others.

The manuring of Hevea is discussed by Anstead (*Agric. Journ. India*, 1918, **13**, 660). Although the results of nearly all experiments made so far show that unmanured plots give yields as good as, or better than, those from manured plots, it is generally agreed that manuring is beneficial. Manured trees have a more healthy appearance and show a greater increase in girth, when not planted so closely as to encourage height at the expense of girth, and, as such trees would afford a larger area of bark available for tapping, they should eventually give better yields. The use of lime has given very encouraging results in South India, and one estate on laterite soil has adopted a regular system of treatment since the trees were one year old. This consists of the application of 10 cwts. of slaked lime per acre, broadcasted and forked in, whilst a heavy crop of *Crotalaria striata* is grown as a green manure and regularly cut and buried. The latter crop has proved useful in preventing soil erosion and in supplying the organic matter much needed on such soil. No control plot of untreated trees is available for comparison, but the growth of the trees is stated to be exceedingly good, the foliage is very dark green in colour (unmanured trees often have a yellow appearance), and

the area has given good yields on tapping, compared with those from trees of similar age growing on richer soil. In order to test the theory that an increase in girth due to manuring results in an improved yield of rubber, it would be necessary to compare two plots of untapped trees, one manured and the other untreated, through a whole cycle of tapping of virgin bark and also tapping of the first renewal of bark; such an experiment would take about eighteen years. The author recommends a new series of experiments to investigate the influence of manures on trees widely spaced from the start and also on trees thinned out early in their growth; due precautions would, of course, have to be taken to allow for errors of experiment, and a definite system of tapping must be adhered to during the whole of the experiment.

Growth of Tree.—Investigations into the increase in girth of rubber trees at the Besoeki experiment station by Keuchenius (*Archief voor Rubber-cultuur in Nederlandsch-Indië*, 1918, **2**, 431) show that growth is not regular throughout the year, and that the trees each year pass through a period during which no growth occurs, a point already noted by Petch. Rainfall is stated to have no effect on the periodicity of growth, the rainfall during one quarter of the year having no influence on growth during the same or the following quarter; growth appears to depend entirely on the total yearly rainfall. Robusta coffee grown as a catch-crop retards the growth of Hevea-trees to a small extent. On good soil with Robusta coffee as a catch-crop Hevea-trees at an elevation of 1,800 ft. in the Besoeki district may be expected to increase in girth about 3¼ in. per year, and should be tappable after 5 years; at 2,800 ft. the trees do not reach a tappable stage before 8 years.

Tapping.—According to de Vries (*Ibid.*, p. 453) heavy tapping, with two left-hand cuts on one-half or three-quarters of the circumference of the tree, causes a very marked fall in the rubber content of the latex; latex containing about 45 per cent. of rubber at the commencement of tapping falling to about 7 per cent. at the end of the experiment. Vulcanisation experiments on the rubber produced showed that the tensile strength remained constant, but that the time of cure decreased from 170 minutes at the commencement to 105 minutes towards the end of tapping.

Structure of Bark.—Investigations by Bobilioff (*Ibid.*,

p. 517) into the relationship between the anatomical structure of the cortex of Hevea-trees and the yield of latex show that trees giving good yields of latex have a larger number of rows (as many as 34) of laticiferous vessels in the soft part of the cortex, while poor yielders have a smaller number of rows of vessels (the smallest number observed being 2). Further, the ratio between the amounts of soft cortex and hard cortex containing stone cells is higher in good yielders.

The number of rows of cortex, their character, and the proportions of soft and hard cortex must be considered together in order to arrive at a correct idea of the type of cortex and consequently the yield of any given tree. Examination of the cortex enables a classification of trees as good, average, or bad yielders to be made. The number of rows of laticiferous vessels is almost the same in renewed bark as in the old cortex of the same tree.

Painting of renewing Bark.—The effect of applying various preservatives to the renewing bark has been investigated by Petch (*Leaflet* No. 9, 1918, *Dept. Agric., Ceylon*). The preservatives tested include all those commonly used, such as coal tar, liquid fuel, " Brunolinum," etc. In these experiments no wounds were caused by the application of preservatives, nor did spontaneous exudation of latex (" bleeding ") occur. On some estates, however, extensive bleeding has occurred, large wounds have been formed, and the renewing bark has been attacked by borers. The author states that all the cases submitted to him of large wounds reputed to have been caused by the application of tar and tallow, or tar and liquid fuel, have been old wounds which must have existed before the application of preservatives.

Preparation of Rubber.—De Vries and Hellendoorn have made an elaborate series of experiments to investigate the differences in weight of rubber obtained in preparing sheet and crêpe (*Archief voor Rubber-cultuur in Nederlandsch-Indië*, 1918, **2**, 393).

Differences in weight may be due to :

(1) Differences in ratio between first- and second-grade rubber produced ; this aspect of the question was not investigated by the authors.

(2) Actual losses of rubber—these may occur owing to (*a*) loss of rubber in the serum due to incomplete coagulation ; this possibility is, in the opinion of the authors, exaggerated, and even when a small amount of rubber is lost in this way the cost of additional acetic acid to obtain

clear serum is often greater than the value of the rubber lost; or (*b*) losses during preparation, such as loss of fragments of crêpe in machinery and of films in the coagulating vessels; such losses should be small in a well-managed factory.

(3) Differences in moisture and in the amount of serum substances retained by the rubber, the latter being considered by the authors as the chief cause of the differences in weight; sheet rolled a few hours after coagulation shows a marked increase in yield ($1\frac{1}{2}$–$2\frac{1}{2}$ per cent.), largely due to moisture probably retained by serum substances which are hygroscopic.

The authors' experiments showed that differences in weight may amount to 1 per cent. for crêpe prepared in different ways, and 3 per cent. for sheet, while the difference between sheet and crêpe may vary from $+3$ to $-1\frac{1}{2}$ per cent. Modern factory methods, such as dilution of latex, soaking the coagulum or sheets in water and rolling on the day following coagulation, all tend to minimise differences in yield, so that on estates the difference is generally under 0·5 per cent., and crêpe may show a greater yield than sheet. Smoking of sheet causes an increase in weight, the reason of which remains to be investigated.

Coagulation.—Whitby has made further experiments on the causes of natural coagulation of rubber latex, and on its coagulation by acids (*Agric. Bulletin, F.M.S.*, 1918, **6**, 374). His results lead him to support the theory that enzyme action is responsible for the natural coagulation of latex, and he therefore agrees with previous work on the subject by Barrowcliff and by Campbell. Whitby also considers that enzyme action is the real cause of coagulation when acid is added to the latex in the usual way, the acid serving as an activator of the enzyme. Natural acidity of the latex may possibly serve to start enzyme action. The author considers that the coagulation of milk by rennin offers a close analogy to the coagulation of Hevea latex.

Viscosity of Rubber.—The relationships between viscosity and the various characters of rubber such as tensile strength, time of cure, etc., are discussed by de Vries (*Archief voor Rubber-cultuur in Nederlandsch-Indië*, 1918, **2**, 481). Although certain factors, such as the nature of the coagulant and the method of drying the rubber, appear to have a definite influence on viscosity, no obvious connection exists between viscosity and tensile strength or rate of cure.

Ultée (*Ibid.*, p. 345) also shows that viscosity is influenced by the nature of the coagulant and also by other chemicals (*e.g.* sodium bisulphite) used in the preparation of rubber.

Bibliography. — Rutgers has collected a bibliography of rubber literature covering the period 1910–16 (*Mededeelingen, Algemeen Proefstation, A.V.R.O.S., Rubberserie*, No. 5). It deals chiefly with cultivation, tapping, diseases, preparation, etc., and contains comparatively few references to literature dealing with chemistry and technology; but the author does not profess to make this branch comprehensive. Brief notes of the contents of the more important articles or books are given (in Dutch), and this bibliography will prove a most valuable source of reference to all interested in rubber.

Fibres

Flax. — In this Bulletin (1914, **12**, 211) reference was made to the experimental cultivation of flax in the East Africa Protectorate, and a report was published on the results of the examination at the Imperial Institute of four samples grown at the Government Experiment Farm at Kabete. In a later issue (1917, **15**, 125) a short account was given of the progress of the flax industry in the Protectorate. A further report on this subject has appeared in the *Ann. Rep. Dept. Agric., British East Africa*, 1916–17. A number of factories have been erected in various parts of the country and large quantities of flax straw are stacked on the farms ready for scutching. Difficulty has been experienced in obtaining scutching machinery from the United Kingdom, but a local firm of engineers have given attention to the manufacture of such plant and hope to be able to meet all the requirements. A consignment of flax exported to England realised £220 per ton, which was then the current market price for higher-grade flax. In order to encourage the industry, a pamphlet on flax cultivation, treatment, and grading has been printed by the Department of Agriculture and distributed to the settlers.

During recent years attention has been directed to the possibilities of flax cultivation in Australia. In 1907 a Commission was appointed to investigate the matter with a view to stimulating the industry; but its efforts were not very successful. Since that time the Commonwealth Government have paid the growers a bounty of 10 per cent. of the value of their crop. In Victoria, particularly in the Drouin district, Gippsland, the area

devoted to flax has varied from 190 to 1,200 acres during different seasons, this fluctuation being attributed to the difficulty of securing labour, ignorance as to the methods of treating the crop, and the absence of a definite market.

Early in 1918 a Committee was appointed by the Commonwealth Government under the War Precautions Flax Regulations. A report of the progress made by this Committee has been published in the *Report of the Executive Committee of the Commonwealth Advisory Council of Science and Industry for the year ended June 30th*, 1918. Enquiries were made with regard to the possibility of securing seed in the different States, but, owing to the limited quantity obtainable and the fact that scutching mills are only available in Gippsland, it was decided to confine the cultivation to that locality for the first season. Samples of seed were distributed to other places, however, for experimental work, and the results obtained in these areas will be considered by the Committee in connection with the question of extending the cultivation next season.

The total area sown in Gippsland in 1918 was about 1,600 acres, of which 1,150 acres were in the Drouin-Warragul district, and 450 acres in the vicinity of Koo-wee-rup. The increased acreage necessitated the erection of additional machinery, and this matter was dealt with by the Committee. Consideration is being given to the cost of flax production and the price which should be paid to the flax miller. It is hoped that the trials now being made in Gippsland will be sufficiently successful to encourage flax growing on a commercial scale in other districts.

Jute.—It sometimes happens that, on opening a bale of jute, the fibre at the centre of the bale is found to have become quite rotten and is then said to have suffered "heart damage." This deterioration is attributed chiefly to the fraudulent practice of watering the jute before shipment. A report on an investigation of the conditions necessary for the production of heart damage has been made by R. S. Finlow, B.Sc., F.I.C., Fibre Expert to the Government of Bengal, and has recently been issued under the title of "Heart Damage in Baled Jute" in the *Memoirs of the Department of Agriculture in India* (*Chemical Series*, 1918, **5**, 33). The work on which the report is based was commenced in 1907 in collaboration with Messrs. Cross and Bevan.

Heart damage never occurs in good, dry fibre and only takes place in presence of an excess of water such as could never be attained by absorption from the atmosphere even under the most humid conditions. When,

however, jute is baled in a wet state, a rise of temperature takes place in the interior of the bale up to a maximum of about 40° C. (104° F.), which is due to a fermentative action, caused by certain bacteria which attack the cellulose of the fibre and apparently effect its hydrolysis. As a result, the fibre loses its tensile strength and becomes useless for spinning; in extreme cases it becomes a spongy, brittle mass which can easily be rubbed to powder. The chief chemical changes produced in the fibre by this bacterial fermentation are: (1) a great reduction in the percentage of cellulose; (2) the rendering of a large proportion of the fibre (up to as much as 60 per cent.) soluble in water or in dilute acid or alkali; and (3) a diminution in the yield of furfurol on boiling the fibre with hydrochloric acid.

Bacteria have been isolated from such damaged jute which produce the typical characteristics of heart damage in the laboratory. Very often a white, beady organic growth appears on the damaged fibre, but this is frequently masked, especially in the case of excessively watered bales, by the black spores of a mould which has been identified by Dr. E. J. Butler, the Imperial Mycologist, as *Aspergillus fumigatus*, Fres. This mould probably does not play any part in causing the damage, but appears to develop on the products of the decomposition of the fibre. It has been stated that this mould possesses pathogenic properties, and sometimes causes deafness in man as well as a lung disease resembling phthisis.

The development of heart damage depends not only on the proportion of water present, but also on the tightness with which the fibre is packed. Thus it has been found that small masses of loose jute will probably not suffer damage in presence of less than 45–50 per cent. of moisture and that "kutcha" bales (of about 280 lb.) require over 30 per cent., whilst "pucca" bales (of about 400 lb.) which are subjected to a pressure of 2 tons per square in., will develop heart damage with only about 25 per cent. of moisture.

"Ship damage" of baled jute which appears, not in the interior, but in the outer layers of the bale, is apparently due to the same organisms which cause heart damage. This deterioration of the fibre takes place in bales of jute which are stowed in a badly ventilated ship's hold, and become damp externally by repeated condensations of moisture from the air.

Sisal Hemp.—An account of the Sisal hemp industry of the East Africa Protectorate has been given in this

BULLETIN (1915, 13, 434). Information on the progress of the industry has been published in the *Ann. Rep. Dept. Agric., British East Africa*, 1916–17, in which it is estimated that the area devoted to this crop now amounts to 15,000 acres. The production amounts to about 400 tons per month, and it is expected that it will soon increase to between 700 and 800 tons per month, or about 8,000–9,000 tons a year. A hydro-electric plant has been erected about 3½ miles below the junction of the Chania and Thika Rivers for the purpose of supplying power to certain Sisal hemp factories, and similar schemes are under consideration for providing electric power for other factories. There is a practically unlimited area in the Protectorate suitable for Sisal cultivation, and the further development depends on the introduction of capital and the supply of the necessary labour.

Cotton

Nyasaland.—In the *Ann. Rep. Dept. Agric., Nyasaland*, 1917–18, reference is made to the position of the cotton industry. The area planted during the year under review amounted to 28,372 acres, as compared with 29,580 acres in the previous year. Owing to the demands on labour for military purposes, the cultivation of the crop was somewhat neglected, with the result that the average yield of lint per acre was only about 63 lb. The returns for the different districts show that cotton succeeds much better at the lower elevations than in the Highlands. The highest yield (105 lb. per acre) was obtained in West Shire, which is followed by 100 lb. per acre in Lower Shire and 80 lb. per acre in Ruo; the high level district of Blantyre gave only 39 lb. per acre, and Zomba 72 lb. per acre. The figures indicate that cotton cultivation in the Highlands cannot be profitable when prices decline from their present high level. Blantyre is too cold and exposed for cotton growing, but there are thousands of acres in the Lower Shire, West Shire and Upper Shire Districts and bordering Lake Nyasa which are well suited to the crop. In general, cotton cultivation is not recommended in Nyasaland at elevations over 2,600 ft. The cotton produced by European planters was only 4,448 bales of 400 lb. each, valued locally at £74,133. Experiments carried out with Nyasaland cotton and imported varieties have shown that the former is best adapted to local conditions. Selected seed of Nyasaland Upland met an increased demand both in the Protectorate itself and in the adjoining Rhodesian and Portuguese territories.

Trials made with Uganda seed gave lower yields than those obtained with Nyasaland cotton, and the plants showed much diversity, some yielding fibre of a greater length than the Nyasaland variety, and some much shorter. The best types were selected with a view to further trials. Several varieties of long-stapled American upland cotton were tested at Namivawa, but none of them compared favourably with locally acclimatised Nyasaland Upland.

The native cotton crop amounted to 1,070 tons of seed-cotton, which is 126 tons in advance of the previous year's production. The Official District Returns of seed-cotton at the various markets were as follows: Mlanje, 230 tons; Lower Shire, 216 tons; West Shire, 196 tons; Upper Shire, 187 tons; Ruo, 186 tons; South Nyasa, 54 tons. This result is very encouraging, and indicates that the native industry is well established, since it has proved itself able to maintain its position in spite of the heavy demands on native labour for military porterage.

Uganda.—In the *Ann. Rep. Dept. Agric., Uganda*, 1916–17, it is estimated that in that year 129,833 acres were planted with cotton, the whole of the seed employed being derived from selections made at the Kadunguru Plantation. The seed was of the Sunflower variety, and was obtained from the restricted seed area of Serere County, having been propagated from selections made on the plantation in 1912. On account of the wet and cold weather which prevailed, the yield per acre was the lowest on record, and the crop contained a large percentage of stained and immature fibre. In places where the crop was successful, however, the cotton showed a distinct improvement in quality, being more regular, finer, stronger and with a better twist than in previous years. The quantities of seed-cotton sold in the different districts were as follows: Lango, 1,590 tons; Teso, 6,658 tons; Bukedi, 2,064 tons; Busoga, 4,861 tons; making a total for the Eastern Province of 15,173 tons. In Buganda Province 3,486 tons were sold. Practically the whole of the cotton is now ginned and baled in the Protectorate; new ginneries have been erected at Kalaki in Lango and Kidongole in Teso, and others are in course of construction in other parts of the country. The exports of cotton were 77,961 cwts. of ginned and 32 cwts. of unginned as compared with 91,231 cwts. and 8,110 cwts. respectively in the preceding year. The value of the crop was greater than that of the previous year, however, being £348,914 as against £245,426. The yield of the Uganda cotton on ginning appears to vary in different parts of the country.

Tests made with 21 samples from the Teso and Lango Districts gave yields ranging from 25·5 to 32·8 per cent., with an average of 30·5 per cent. The Agricultural Department realises the importance of maintaining a high ginnery yield, and are making efforts to improve the cotton in this respect.

Burma.—An account of the cottons of Burma and of experiments which have been made during recent years with a view to the improvement of the industry is given in the Report of the Imperial Cotton Specialist, which has been published in *Scientific Reports, Agric. Res. Inst., Pusa*, 1917–18, p. 141. The following varieties of cotton are at present grown in Burma:

(1) "Wagale" (*Gossypium neglectum* var. *Burmanicum*), with yellow flowers. This is the most important of the Burmese cottons, and forms the greater part of the crop. The lint is of a quality midway between Bengals and Khandesh. A large number of single plant selections of "wagale" were made in 1914, and their ginning yield determined; the best of these were retained and grown in 1915, and since then the pure strains have been cultivated. This cotton grown on the Tatkon farm in the Yamethin District now gives a ginning yield of 36 per cent.

(2) "Wapyu" (*G. neglectum* var. *avense*), with white flowers. This variety is said to produce longer bolls and whiter lint than "wagale." A promising hybrid has been obtained on this farm between this variety and Shan State cotton, which gives a ginning out-turn of 40 per cent. and is now being tested on the large scale.

(3) "Wani" (*G. neglectum* var. *kokatia*), with yellow flowers. The lint of this variety is khaki-coloured and chiefly used for making jackets. Plants of this type sometimes occur among the local early cotton crop, and the khaki cotton is picked out before ginning.

(4) "Wagyi" (*G. obtusifolium* var. *Nanking*). This variety is grown in Prome and Thayetmys districts and occupies the ground for nine months. The lint is superior to that of the local early type "wagale," but the longer period of growth renders the plant unsuitable for the Burmese cultivator. Crosses between "wagyi" and Broach cotton have been made with a view to the production of an earlier-ripening form, but it is doubtful whether these hybrids will remain fertile.

(5) "Pasi" (*G. neglectum* var. *cernuum*), with yellow flowers. This variety is grown to a small extent by the Kachins in hills of the Namyin Valley of the Myitkyina district, and was probably introduced from the Khasi and

Jaintia hills of Assam. The seeds are sown broadcast together with rice and vegetable seeds; these crops arrive at maturity in succession, the cotton ripening last.

(6) Shan State cotton. The plants of this cotton are said to be identical with those of "wagale," but the lint is greatly superior and almost equal to fine Surat. The ginning yield, however, is only 28 per cent., and the variety therefore fails to attract the cultivator.

(7) Pernambuco cotton (*G. brasiliense*). This is a kidney cotton; it is not regularly cultivated, but is grown occasionally as an ornamental plant in gardens. It is stated that trials have been made with this variety near Moulmein, but without success.

Certain other cottons have been submitted to trial in Burma. Egyptian and Upland Georgian varieties were grown for two or three seasons at the Mandalay and Bugi Stations; but the crop was a failure. Cambodia cotton has been tested on the Tatkon farm and "Utopia" (a New Orleans type) on the Padu farm; but these were found to be very liable to insect attack and did not give promising results. On the whole, there is no doubt that the best results will be obtained by the selection of the local types.

It is pointed out that, in order to encourage the extension of cotton growing in Burma, the grower should be given a reasonable price for his crop, that ginneries should be erected in suitable localities, and that the drill should be used for sowing in order to avoid the waste of seed and ensure more even growth and a better yield.

NOTICES OF RECENT LITERATURE

THE NATURAL ORGANIC COLOURING MATTERS. By Arthur George Perkin, F.R.S., F.R.S.E., F.I.C., and Arthur Ernest Everest, D.Sc., Ph.D., F.I.C. Pp. xxii + 655, Demy 8vo. (London: Longmans, Green & Co., 1918.) Price 28*s.* net; post free, United Kingdom 28*s.* 6*d.*, abroad 28*s.* 8*d.*

This volume, issued in the series of Monographs on Industrial Chemistry, edited by Sir Edward Thorpe, gives a full and complete account of the present state of knowledge of the natural organic colouring matters. In the introduction, an historical review is given of the discovery and use of the more important natural dyestuffs and the investigation of their chemical constituents. In the succeeding chapters the products

are grouped according to the constitution, where known, of their chief tinctorial constituents. Information is furnished regarding the botanical origin and geographical distribution of each vegetable dyestuff and the method of extracting the colouring matter from it. An account is given in each case of the properties of the colouring matter and of the researches which have been made with a view to the isolation and purification of the tinctorial principles and the determination of their chemical constitution, reference being made throughout to the original papers in which the investigations are recorded.

The work will be of the greatest service to workers in this branch of chemical technology, as there is no other book in the English language dealing in any detail with the subject in the light of modern research.

Oils, Fats and Waxes. By Percival J. Fryer, F.I.C., F.C.S., and Frank E. Watson, B.Sc., F.I.C. Vol. II, Practical and Analytical. Pp. xvi + 314, with 69 illustrations, Demy 8vo. (Cambridge: University Press, 1918.) Price 16*s.* net; post free, United Kingdom and abroad, 16*s.* 6*d.*

The present volume, completing this handbook, the first volume of which was noticed in a previous number of this Bulletin (1917, **15**, 461), deals with practical and analytical methods. As in the former volume, the information is given in a very condensed form, but it does not appear that any essential details have been left out, and no serious omissions of important methods of examination of materials are evident.

The book is intended for the use of technical chemists and of students. The earlier sections of the book contain a good deal of elementary information relating to analytical procedure, illustrated by diagrams and reproductions of photographs. In several cases these represent simple operations or apparatus with which any student qualified to embark on the examination of oils should be conversant (*e.g.* the illustrations on pp. 10, 11 of the methods of using a pipette and a burette, respectively). The space devoted to such elementary details might have been devoted more advantageously to more detailed accounts of important methods.

The book will undoubtedly prove useful as a work of reference for technical chemists, replacing in many cases the detailed and somewhat cumbrous works of other authors, and will also be valuable to students who wish to gain rapidly a clear understanding of the methods of analysis of oils, fats and waxes.

An excellent feature, which is unfortunately often omitted in technical books, is the section dealing with the interpretation of results. This section is illustrated with examples of the results of the examination of various materials, and the deductions drawn from the results obtained are clearly discussed.

THE PRINCIPLES OF BLEACHING AND FINISHING OF COTTON. By S. R. Trotman, M.A., F.I.C., and E. L. Thorp, A.C.G.I., A.M.I.E.E. 2nd Edition, revised. Pp. xii + 347, with 131 illustrations, Med. 8vo. (London: Charles Griffin & Co., Ltd., 1918.) Price 21*s.* net; post free, United Kingdom and abroad, 21*s.* 9*d.*

The methods employed in bleaching and finishing cotton are largely empirical, having been gradually developed from the experience of past generations. It is therefore somewhat remarkable that the processes have, in general, proved to be based on sound scientific principles. It is pointed out, however, by the authors of the book under notice that future advance in practice will necessitate the carrying out of original constructive experiments, and that for success in this direction a knowledge of the underlying chemical and physical principles is essential.

The work has therefore been written with the object of enabling the practical student to gain an insight into the principles of the processes he is called upon to control and to work for desired results on scientific lines.

The subjects dealt with include the structure and composition of cotton fibre, and methods of testing it; the properties and general chemistry of starch, cellulose, and other carbohydrates; water supplies and the methods of softening water; the chemistry of soap and soap-making, and of the various materials used in the bleaching and finishing processes. A full and practical account is given of the methods employed for bleaching, washing, souring, mangling, drying, conditioning, stiffening, stentering, beetling and calendering, and a well-illustrated description is provided of the various machines and appliances used in these processes.

The book has, no doubt, already proved of much service to those engaged in the bleaching and finishing of cotton goods, and this is indicated by the fact that the first edition has become exhausted.

THE SPINNING AND TWISTING OF LONG VEGETABLE FIBRES (FLAX, HEMP, JUTE, TOW AND RAMIE). By Herbert R. Carter. 2nd Edition, revised and enlarged. Pp.

xvi + 434, with 216 illustrations (including 4 plates), Med. 8vo. (London: Charles Griffin & Co., Ltd., 1919.) Price 24*s.* net; post free, United Kingdom 24*s.* 9*d.*, abroad 24*s.* 10*d.*

This work, the first edition of which was noticed in this BULLETIN (1905, **3**, 104), gives a practical account of the most modern methods of hackling, carding, preparing, spinning and twisting the long vegetable fibres of commerce. It has now been thoroughly revised and brought up to date, and many new illustrations have been introduced. The improvements thus effected have greatly enhanced the value of the book, and will enable it to maintain its position as a standard manual for the use of managers of spinning mills and rope works and others engaged in the textile industries.

AGENDA DU CHIMISTE PARFUMEUR. By R. M. Gattefossé. Followed by LA TEINTURE DES CHEVEUX. By A. Chaplet. Pp. 312, Demy 8vo. (Paris: Editions Scientifiques Françaises, 1918.)

This volume, which forms a handbook for the perfumer, contains an account of the raw materials used in perfumery, tables of the essential oils and their principal constituents, and information on the manufacture of perfumes, essences, cosmetics and various toilet preparations, the methods of scenting soaps, and other matters relating to the perfumery industries. Numerous formulæ are given for the manufacture of perfumes, cosmetics, etc. The last chapter deals with the methods of bleaching and dyeing the hair, and gives a number of recipes for hair-dyes.

CATALYSIS IN INDUSTRIAL CHEMISTRY. By G. G. Henderson, M.A., D.Sc., LL.D., F.R.S. Pp. x + 202, Demy 8vo. (London: Longmans, Green & Co., 1919.) Price 9*s.* net; post free, United Kingdom and abroad, 9*s.* 6*d.*

This book is issued in the series of Monographs on Industrial Chemistry, edited by Sir Edward Thorpe.

In an introductory chapter the author discusses the various classes of catalytic action, the theories which have been advanced to explain the mechanism of such reactions, and the phenomena of autocatalysis and negative catalysis, and gives a brief description of the methods of obtaining active forms of a few of the metallic catalysts in general use. In succeeding chapters an account is given of the employment of catalysts in many industrial

processes, including the manufacture of hydrogen, chlorine, graphite, sulphuric acid, ammonia and nitric acid. Special attention is devoted to the catalytic processes of hydrogenation and particularly with reference to the hydrogenation of oils ("hardening of fats") and other industrial applications. Other sections deal with processes of dehydrogenation, oxidations, hydration and hydrolysis, dehydration, polymerisation (including the preparation of synthetic rubbers), condensation and the preparation of various organic compounds. Reference is also made to the influence of catalysts in accelerating the process of vulcanising rubber, to the action of enzymes, and to the part played by catalysis in the production of light by means of incandescent mantles and in processes of surface combustion.

The work presents an interesting account of the numerous and varied applications of catalysis in industrial chemistry, with copious references to original papers and patent specifications, and forms a valuable and useful monograph on the subject.

Powdered Coal as a Fuel. By C. F. Herington. Pp. xi + 211, Med. 8vo. (London: Constable & Co., Ltd., 1918.) Price 12*s.* 6*d.* net; post free, United Kingdom and abroad, 13*s.*

In this work the author describes in simple terms the possibilities and advantages of using powdered coal, and gives an account of its application to various industrial purposes in America. Numerous illustrations of a sufficiently detailed character allow the reader to follow with ease the descriptions of the various mechanical and metallurgical appliances. A comparison of the respective cost and efficiency of ordinary coal, oil, water gas and powdered coal is given wherever possible.

The subject is dealt with in a practical manner under the headings of a General Introduction, Coals Suitable for Powdering, Preparation of Powdered Coal, Feeding and Burning Powdered Coal, Powdered Coal in the Cement Industry, Powdered Coal in Metallurgical Furnaces, Powdered Coal under Boilers, Powdered Coal for Locomotives.

The author advocates the wider use of coal in a powdered form. It is worthy of note that already 8,000,000 tons of powdered coal are consumed annually in the United States, and its use is increasing.

In the final chapter on Explosions the author perhaps unduly minimises the danger of explosions in the use of powdered coal and quotes an authority who states "that there is absolutely no danger of explosions of powdered

coal where sensible precautions are observed." It would surely be more correct to admit that the danger is considerable in spite of precautions, which minimise rather than annul the risk of explosion.

The book concludes with a useful bibliography.

BOOKS RECEIVED

The Pacific: Its Past and Future, and the Policy of the Great Powers from the Eighteenth Century. By G. N. Scholefield, B.Sc. (Econ.) Lond. Pp. xii + 346, Med. 8vo. (London: John Murray, 1919.) Price 15*s.* net; post free, United Kingdom and abroad, 15*s.* 7*d.*

Stewart's Handbook of the Pacific Islands. A Reliable Guide to all Inhabited Islands of the Pacific Ocean for Traders, Tourists and Settlers. Compiled by Percy S. Allen. Pp. 286, Demy 8vo. (Sydney, N.S.W.: McCarron, Stewart & Co., Ltd., 1918.)

The South and East African Year Book and Guide. Edited annually by A. Samler Brown, F.R.M.S., and G. Gordon Brown, F.R.G.S., for the Union-Castle Mail Steamship Company, Ltd. 1919 Edition (25th Edition). Pp. liii + 773. (London: Sampson Low, Marston & Co., Ltd.) Price 2*s.* 6*d.* net; post free, United Kingdom and abroad, 3*s.*

The Grasses and Grasslands of South Africa. By J. W. Bews, M.A., I.S.C. Pp. vi + 161, Med. 8vo. (Pietermaritzburg: P. Davis & Sons, Ltd., 1918.)

Productive Sheep Husbandry. By W. C. Coffey. Pp. x + 479, Demy 8vo. (Philadelphia and London: J. B. Lippincott Company, 1918.) Price 10*s.* 6*d.* net; post free, United Kingdom and abroad, 11*s.* 3*d.*

The Mica Miner's and Prospector's Guide. By A. A. C. Dickson, F.G.S., A.I.M.M., etc. Pp. viii + 50, Crown 8vo. (London: E. and F. N. Spon, Ltd., 1919.) Price 4*s.* 6*d.* net; post free, United Kingdom and abroad, 4*s.* 9*d.*

Directory of Paper-Makers of the United Kingdom for 1919. 43rd Annual Publication. Pp. 260, Super Roy. 8vo. (London: Marchant, Singer & Co.) Price, post free, United Kingdom 2*s.* 6*d.*, abroad 2*s.* 9*d.*

REPORTS OF RECENT INVESTIGATIONS AT THE IMPERIAL INSTITUTE

The following summaries have been prepared from a selection of the Reports made by the Director of the Imperial Institute to the Dominion, Colonial and Indian Governments.

INVESTIGATIONS OF MATERIALS SUGGESTED FOR THE MANUFACTURE OF PAPER

(SOUTH AFRICA, RHODESIA, EGYPT, PAPUA, ST. HELENA)

In the following pages an account is given of the results of examination at the Imperial Institute of a number of materials which have been investigated recently in order to ascertain their suitability for the manufacture of paper. Some of the more important of such products previously dealt with in this Bulletin are included in the following list; others are referred to in connection with the materials considered in the present article: Elephant grass (1913, **11**, 68), bamboo grass (1918, **16**, 273), *Ecdeiocolea monostachya* leaves (1917, **15**, 1), sunflower stems (1917, **15**, 332), linseed stalks (1917, **15**, 481), rice straw (1918, **16**, 21), Brachystegia bark (1917, **15**, 6), baobab wood and bark (1917, **15**, 326), spent wattle bark (1917, **15**, 500), black wattle wood (1917, **15**, 501), *Neoboutonia macrocalyx* wood (1917, **15**, 4).

1. South Africa

In continuation of the investigation of grasses from South Africa previously recorded in this Bulletin, five different kinds were examined this year, viz., *Cymbopogon Ruprechti*, *Cymbopogon* sp., *Trachypogon polymorphus*,

Themeda Forskalii var. *mollissima*, and *Tristachya Rehmanni*, whilst a sample of *Panicum obscurens* was examined in 1918. The first three gave similar results, and it will be convenient to deal with them together in the present account. The grasses previously examined included tambookie grass, *Cymbopogon nardus* var. *vallidus* (this BULLETIN, 1916, **14**, 163); Johnson grass, *Sorghum halepensis* (1918, **16**, 127), thatching grass or dek gras, *Andropogon Buchananii* (*loc. cit.* p. 129); tambookie grasses, *A. Dregeanus* and *A. auctus* (*loc. cit.* p. 130); and *A. hirtiflorus* var. *semiberbis* (*loc. cit.* p. 133).

(1) *Cymbopogon Ruprechti*

This species is one of the tambookie grasses, and is stated to be plentiful around Rustenburg and on the northern slopes of the Magaliesberg.

The sample was very similar to the tambookie grasses previously received from South Africa which were identified as *Andropogon Dregeanus* and *A. auctus* (*loc. cit.* p. 131). The stems were straw-coloured, and had been cut into lengths of about 3 ft.; they measured up to $\frac{3}{16}$ in. in diameter, and had hard nodes at intervals of 11 to 14 in. The flowering heads and sheathing leaves had been almost completely removed.

(2) *Cymbopogon* sp.

This grass was described in the letter advising the sample as *Cymbopogon excavatus*, but the sample was labelled *Cymbopogon hirtus*. It was stated to be common around Pretoria.

The material consisted of dark straw-coloured grass, similar in general characters to tambookie (*Andropogon* spp.) and other South African grasses of this type previously examined at the Imperial Institute. The stems however were much thinner, being only up to $\frac{1}{12}$ in. in diameter. Many of the sheathing leaves and some flowering heads were still attached to the stems, which had been cut into lengths measuring up to 31 in.

(3) *Trachypogon polymorphus*

This grass belongs to the same sub-tribe of the Gramineæ as the genus *Cymbopogon.* It occurs in tropical and sub-tropical America, and Madagascar, as well as in South Africa, where it is known as "steek" grass.

The sample, which was stated to have been obtained at Rustenberg, consisted of grass cut into pieces about 3 ft. long, and ranging in diameter from $\frac{1}{32}$ to $\frac{3}{16}$ of an inch. In colour and general characteristics the grass resembled the previous sample (No. 2). The flowering heads and sheathing leaves had been removed.

The above three grasses were submitted to chemical examination, in comparison with previous samples of tambookie grass (*Andropogon* spp.) with the following results :

	Cymbopogon Ruprechti.	*Cymbopogon* sp.	*Trachypogon polymorphus.*	*Andropogon Dregeanus.*	*A. auctus.*
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture . .	9·9	8·7	8·5	9·2	9·1
Ash [1] . .	5·5	7·5	5·3	4·5	7·1
Cellulose [1] .	60·6	56·6	57·5	47·5	53·5
Length of ultimate fibres .	0·4 to 3·5 mm., mostly 0·8 to 2·0 mm.	0·3 to 4·9 mm., mostly 2·0 to 3·0 mm.	0·4 to 2·9 mm., mostly 1·0 to 2·0 mm.	0·3 to 3·8 mm., mostly 1·0 to 2·0 mm.	0·3 to 3·9 mm., mostly 1·0 to 2·0 mm.

[1] *Calculated on the dry grass.*

It will be seen from these results that the present samples contained a higher percentage of cellulose than the two previous tambookie grasses. In the latter cases the samples included the flowering heads and sheathing leaves, but in the present samples they had been partly or completely removed.

The grasses were converted into paper pulp by treatment with caustic soda under conditions similar to those employed on a commercial scale. In each case three

experiments were carried out under the following condi-conditions :

Experiment.	Caustic soda used.		Conditions of boiling,	
	Parts per 100 parts of grass.	Parts per 100 parts of solution.	Time.	Temperature.
			Hours.	
A	10	1·5	5	140° C.
B	16	2·5	5	140° C.
C	20	4·0	5	140° C.

The results of the experiments are shown in the following table :

Experiment.	*Cymbopogon Ruprechti.*		*Cymbopogon* sp.		*Trachypogon polymorphus.*	
	Caustic soda consumed per 100 parts of grass.	Yield of dry pulp.[1]	Caustic soda consumed per 100 parts of grass.	Yield of dry pulp.[1]	Caustic soda consumed per 100 parts of grass.	Yield of dry pulp.[1]
		Per cent.		*Per cent.*		*Per cent.*
A	7·6	58	8·3	56	8·1	53
B	9·8	54	10·4	47	9·8	51
C	10·4	52	11·0	44	10·7	48

[1] *Expressed on grass as received.*

All three grasses thus gave good yields of pulp, which was of excellent quality. The pulp obtained in experiment A in each case could not be bleached, whilst that of experiments B and C bleached either to a pale cream colour or became almost white. Both the unbleached and bleached pulps were very similar in character to those prepared from the two tambookie grasses (*Andropogon* spp.) previously examined at the Imperial Institute.

The results of this investigation show that these grasses give very good yields of pulp which compare favourably with the yields obtained from esparto grass under similar conditions. The pulp in each case furnished paper of similar character to that obtained at the Imperial Institute with the pulp from previous samples of tambookie and dek grasses, and of *Andropogon hirtiflorus* grass, and behaved in the same way on bleaching.

The yields of pulp from the present three grasses are higher than those obtained from the samples of the

grasses mentioned above, but this is probably due to the fact that the present samples consisted of stems from which practically all the flowering heads and sheathing leaves had been removed, whereas the samples of the other grasses examined consisted of the whole stems.

(4) *Themeda Forskalii* var. *mollissima*

This grass is stated to be one of the most widely distributed grasses in South Africa.

The sample, which was gathered on virgin veld at the Botanical Station, Pretoria, had been cut into lengths of about 3 ft. It consisted of tapering stems about ⅛ in. in diameter at the base, with hard woody nodes at intervals of 12 to 18 in. A sheathing leaf or the remains of a leaf occurred at each node, and the internodes were filled with soft pith.

The grass was chemically examined with the following results :

	Per cent.
Moisture	10·6
Ash [1]	5·0
Cellulose [1]	55·1
Length of ultimate fibres	0·8 to 3·8 mm., mostly 1·5 to 2·0 mm.

[1] *Calculated on the dry grass.*

The grass was treated with a solution of caustic soda under conditions similar to those used for the production of paper pulp on a commercial scale, with the results shown in the following table :

Experiment.	Caustic soda used.		Conditions of boiling.		Caustic soda consumed per 100 parts of grass.	Yield of dry pulp expressed on grass as received.
	Parts per 100 parts of grass.	Parts per 100 parts of solution.	Time.	Temperature.		
			Hours.			*Per cent.*
A	8	2	5	140° C.	7·5	52
B	12	3	5	140° C.	9·0	48
C	16	4	5	140° C.	10·0	44
D	20	4	5	140° C.	12·4	42

The pulp obtained in these experiments yielded a strong, opaque paper which did not shrink appreciably on drying. The pulps obtained in experiments A and B did

not bleach well, but those obtained under the more drastic conditions of experiments C and D bleached easily to a pale cream colour.

The results show that *Themeda Forskalii* grass yields about the same quantity and quality of pulp as other South African grasses, such as tambookie and dek grass, already examined at the Imperial Institute. The nodes of the grass are however harder than those of tambookie and dek grass, and would necessitate thorough boiling and beating, in order to break them up completely and obviate the presence of yellowish specks in the paper.

This *Themeda Forskalii* grass could not be remuneratively exported to Europe as a paper-making material, but it could probably be employed in South Africa as a source of paper pulp for local use or for export. As indicated above, however, the hard nodes of the grass are a disadvantage, and although they could probably be completely broken up when treating the grass on a commercial scale, their presence would be likely to detract from the market value of the grass as a paper-making material.

(5) *Tristachya Rehmanni*

This is a coarse tufted grass, similar in habit to the Cymbopogons, but belonging to a different tribe of the Gramineæ. It is common in the Transvaal High Veld; the present sample was stated to have been gathered at Rustenburg.

The sample consisted of pale brownish-green tapering stems of circular cross section, measuring from $\frac{1}{16}$ to $\frac{1}{12}$ in. in diameter at the base. All the leaves and flowering heads had been removed. The stems, which were filled with soft pith, each had one or two nodes a few inches from the apex, but were otherwise free from nodes.

The grass was submitted to chemical examination at the Imperial Institute with the following results:

	Per cent.
Moisture	9·3
Ash [1]	3·3
Cellulose [1]	55·8
Length of ultimate fibres	0·4 to 2·2 mm., mostly about 1·0 mm.

[1] *Calculated on the dry grass.*

The grass was converted into paper by treatment with caustic soda under conditions similar to those used on a commercial scale, with the following results :

Experiment.	Caustic soda used.		Conditions of boiling.		Caustic soda consumed per 100 parts of grass.	Yield of dry pulp expressed on grass as received.
	Parts per 100 parts of grass.	Parts per 100 parts of solution.	Time.	Temperature.		
			Hours.			*Per cent.*
A	10	1·5	5	140° C.	8·5	51
B	16	2·5	5	140° C.	10·0	45
C	20	4·0	5	140° C.	13·2	42

It will be seen that this grass gave good yields of pulp, but the pulp furnished a rather weak, opaque paper. This inferiority in strength is almost certainly due to the shortness of the ultimate fibres. The pulp obtained in experiment A was somewhat underboiled and therefore a little difficult to beat, and it could not be bleached, but the pulps obtained in experiments B and C, which were of very pale green colour, bleached to a pale cream tint.

Owing to the deficiency in strength of the paper furnished by this grass it is on the whole inferior as a paper-making material to most of the other South African grasses so far examined at the Imperial Institute, but it might be utilised locally in admixture with better materials, such as the tambookie grasses.

(6) *Panicum obscurens*

The grass is stated to be very common on the High Veld.

The sample examined consisted of fine, dried, straw-coloured grass, bearing a very large number of small chaffy bracts, the remains of the inflorescence.

The grass was submitted to chemical examination at the Imperial Institute with the following results :

	Per cent.
Moisture	9·2
Ash [1]	5·0
Cellulose [1]	47·2
Length of ultimate fibres	0·3 to 2·3 mm., mostly 0·9 to 1·6 mm.

[1] *Calculated on the dry grass.*

In order to determine the suitability of the grass for paper making, it was treated with varying amounts of caustic soda, under conditions similar to those used for the production of paper pulp on a commercial scale, and the results are shown in the following table:

Experiment.	Caustic soda used.		Conditions of boiling.		Parts of caustic soda consumed by 100 parts of grass.	Yield of dry pulp expressed on grass as received.
	Parts per 100 parts of grass.	Parts per 100 parts of solution.	Time.	Temperature.		
			Hours.			*Per cent.*
A	10	2	5	140° C.	8·2	46
B	16	3	5	140° C.	11·6	43
C	20	4	5	140° C.	12·6	39

The results of these experiments showed that the grass gives a good yield of pulp, which is, however, not of very good quality, as although the paper produced does not shrink on drying, it is marred by the presence of the numerous chaffy bracts, which are resistant to the action of the caustic soda, and give the paper a rough, irregular surface. The bracts are also apparent as bright yellow specks in the bleached paper. A better pulp can be produced by the more drastic treatment of experiment C, *i.e.* by using 20 per cent. of caustic soda, but the bracts are still evident, both in the bleached and unbleached paper, though to a smaller extent than before.

On account of the presence of the small bracts referred to above, and their effect on the paper produced, this *Panicum obscurens* grass is decidedly inferior as a paper-making material to most of the other grasses from South Africa, examined at the Imperial Institute, and would probably only be suitable for the manufacture of cardboard or brown paper.

2. Rhodesia

(1) *Muguguboya Bark*

The sample of Muguguboya bark which is the subject of this report was forwarded to the Imperial Institute from Rhodesia in June 1918.

It was stated that the tree yielding the bark occurs plentifully in the neighbourhood of the Victoria Falls, but

that its botanical identity was not known. It was suggested that the bark might be suitable for the same purposes as Baobab bark.

The sample consisted of pieces of bark measuring up to 15 in. in width, 5 ft. in length, and from 0·3 to 0·45 in. in thickness. The outer bark was smooth, reddish-brown, brittle and thin, measuring about 0·05 in. in thickness. The inner bark, which was of a cream tint, was very fibrous, but somewhat woody and brittle, and lacked the strength and pliability of Baobab bark.

The bark was chemically examined at the Imperial Institute with the following results :

	Per cent.
Moisture	8·9
Ash [1]	9·7
Cellulose [1]	59·2
Length of ultimate fibres	1·2 to 5·8 mm., mostly 2·0 to 3·0 mm.

[1] *Calculated on the dry bark.*

The entire bark as received was submitted to treatment with caustic soda under conditions similar to those employed on a commercial scale for the preparation of paper pulp, and the results are given in the following table :

Experiment.	Caustic soda used.		Conditions of boiling.		Soda consumed per 100 parts of bark.	Yield of dry pulp expressed on the bark as received.
	Parts per 100 parts of bark.	Parts per 100 parts of solution.	Time.	Temperature.		
			Hours.			*Per cent.*
A	16	4	5	140° C.	11·2	45
B	20	4	5	140° C.	12·2	42
C	24	6	7	140° C.	14·0	40

The bark furnishes good yields of very long-fibred pulp, which possesses excellent felting qualities, and gives a very strong, opaque paper which does not shrink on drying.

The unbleached pulps were in all cases of brown colour. The pulp obtained in Experiments A and B did not bleach very easily, giving only a buff-coloured pulp in Experiment A and a cream-coloured pulp in Experiment B. Experiment C was therefore made in order to ascertain

whether by slightly more drastic treatment a pulp could be obtained which would furnish a white product on bleaching. The pulp from this experiment, however, only bleached to a pale cream tint.

The papers obtained in the above experiments all contained brownish specks, possibly derived from the outer bark, and the following experiment (D) was therefore made on the inner bark after the removal of the thin, dark-coloured outer layer :

Experiment.	Caustic soda used.		Conditions of boiling.		Soda consumed per 100 parts of inner bark.	Yield of dry pulp expressed on air-dried inner bark.
	Parts per 100 parts of inner bark.	Parts per 100 parts of solution.	Time.	Temperature.		
			Hours.			*Per cent.*
D	24	6	5	140° C.	14·2	52

The pulp obtained in this experiment was free from dark specks, but it could only be bleached to a cream colour.

The results of this investigation show that a good yield of pulp, furnishing a strong, tough paper, can be obtained from the entire bark of the Muguguboya tree, but that the pulp is rather difficult to bleach and contains brownish specks. The latter defect can be avoided by using only the inner bark, but even in this case the pulp does not bleach easily. The inner bark is comparable as a paper-making material with Baobab bark, which was formerly utilised in Europe for this purpose.

It is improbable that Muguguboya bark could be remuneratively exported to the United Kingdom from Rhodesia, but it might be utilised locally for paper manufacture.

(2) *Mungongo Wood*

Two samples of Mungongo wood (*Ricinodendron Rautanenii*), which is stated to occur in large quantities in Northern Rhodesia, were received in April 1918.

No. 1. "*Mungongo tree block.*"—This sample consisted of a section of the complete tree-trunk showing a few small knots.

No. 2. "*Mungongo tree board.*"—This consisted of a short piece of board free from knots.

The wood of both samples was cream-coloured and very soft and light.

The sample of board (No. 2) was too small for examination, and the investigation was therefore conducted with the section of the tree trunk only.

A chemical examination of the wood gave the following results :

	Per cent.
Moisture	9·8
Ash [1]	3·2
Cellulose [1]	54·3
Length of ultimate fibres	0·7 to 1·7 mm., mostly 1·0 to 1·2 mm.

[1] *Calculated on the dry wood.*

The wood was submitted to treatment with caustic soda under conditions similar to those used on a commercial scale for the production of paper pulp, with the results shown in the following table :

Experiment.	Caustic soda used.		Conditions of boiling.		Soda consumed per 100 parts of wood.	Yield of dry pulp expressed on the wood as received.
	Parts per 100 parts of wood.	Parts per 100 parts of solution.	Time.	Temperature.		
			Hours.			*Per cent.*
A	16	4	8	140° C.	9·6	59
B	20	4	8	150° C.	10·8	53
C	24	4	7	165° C.	12·8	46

The pulp produced in experiment A was distinctly underboiled ; it was very difficult to break up in the beater and could not be bleached. By treatment with larger amounts of caustic soda, as in experiments B and C, pulps of better character were produced, but these pulps also could not be bleached. With reference to these results it may be stated that spruce wood of the kind used in the production of wood-pulp on a commercial scale yields pulp of excellent quality when treated under the conditions of experiment C.

In all three experiments the pulp obtained from the Mungongo wood only yielded paper of moderate strength.

The results of this examination show that Mungongo

wood is not a promising material for the manufacture of paper pulp by the soda process. It is possible that pulp of rather better quality might be obtained by the sulphite process, but a further supply of the wood will be required before trials with this process can be made. It is however unlikely that the pulp from Mungongo wood could compete with that yielded by more promising materials, such as the tambookie and other grasses found in South Africa, which give good yields of pulp of excellent quality (see pp. 142–146, and this BULLETIN, 1918, **16**, 129).

3. Egypt

(1) *Cyperus alopecuroides*

Two samples of the stems of *Cyperus alopecuroides* were received from Egypt in April 1917 and July 1917 respectively.

Sample No. 1.—This consisted of straight greenish-yellow stems which were reddish-brown at the root ends. The stems were of irregular oval cross-section, measuring from 0·1 to 0·3 in. across at the widest part, and from 4 to 6 ft. in length with an average of 5 ft. 6 in. The stems were filled with soft pith, and bore no flowering heads.

Sample No. 2.—This consisted of straight, straw-coloured stems of triangular cross-section, measuring from ¼ to ½ in. in width and from 2 ft. 6 in. to 4 ft. in length. The stems were filled with soft pith and bore characteristic flowering heads.

The samples were submitted to chemical examination with the following results:

	No. 1. *Per cent.*	No. 2. *Per cent.*
Moisture	9·4	9·3
Ash[1]	7·6	7·3
Cellulose[1]	47·6	51·9
Length of ultimate fibres	0·4 to 3·7 mm., mostly 0·7 to 1·5 mm.	0·4 to 3·0 mm., mostly 0·6 to 1·5 mm.

[1] *Calculated on the dry stems.*

The stems were submitted to treatment with caustic soda under conditions similar to those used on a commercial scale for the preparation of paper pulp, with the following results:

Sample.	Experiment.	Caustic soda used.		Conditions of boiling.		Parts of soda consumed per 100 parts of stems.	Yield of dry pulp expressed on stems as received.
		Parts per 100 parts of stems.	Parts per 100 parts of solution.	Time.	Temperature.		
				Hours.			*Per cent.*
No. 1	C	16	4·0	4	140° C.	13·2	38·0
No. 2	A	8	1·7	4½	140° C.	7·2	46·0
,,	B	12	3·0	4	140° C.	11·4	45·0
,,	C	16	4·0	4	140° C.	13·0	42·0
,,	D	20	4·0	4	140° C.	—	39·0

It will be seen from the above figures that sample No. 2 contained more cellulose than sample No. 1, and therefore gave a higher yield of pulp under the same conditions of treatment. This difference is probably due to the samples being of different ages.

The pulps obtained from both samples beat easily and were of light brown colour ; they yielded papers which were strong and opaque, but rather stiff and parchment-like, and showed a distinct tendency to shrink on drying unless great care was taken with the beating, probably owing to the presence of parenchyma from the pith.

The pulps produced in experiments A and B could only be bleached to a rather deep cream colour, and even those produced under the more drastic conditions of experiments C and D did not bleach to a pure white, but only to a very pale cream colour.

The pulp obtained from sample No. 1 was of similar character to that furnished by No. 2, but it bleached to a rather better colour.

The stems of *Cyperus alopecuroides* give a fair yield of pulp of moderate quality, but the presence of a considerable amount of pith may interfere with their utilisation for paper-making. The occurrence of pith cells (parenchyma) in the pulp is liable to cause shrinkage of the paper on drying, and to give it a stiff, parchment-like character ; the presence of pith also frequently hinders the process of bleaching. By moderately drastic treatment (*e.g.* with 20 per cent. of caustic soda) a pulp yielding a fairly white paper of moderate strength can be produced, and it is probable that the removal of parenchyma by washing would improve the quality of the product, although the yield of pulp would be less.

The material could be converted by milder treatment into pulp suitable for the manufacture of brown wrapping papers or cardboard.

It is unlikely that these stems of *Cyperus alopecuroides* could be remuneratively exported as a paper-making material, but they might be utilised in Egypt for this purpose.

(2) *Papyrus Stems*

A sample of the stems of *Cyperus Papyrus* was received from Egypt in October 1917. The material was stated to represent the new growth of 1917.

It consisted mostly of yellow stems of triangular cross-section, measuring 4 to 5 ft. in length, and up to 1 in. in width, and composed of a fibrous sheath filled with soft pith.

Some of the stems in the sample were brown and withered, and only about $\frac{3}{16}$ in. in width.

The material was chemically examined with the following results :

	Per cent.
Moisture	10·0
Ash [1]	7·7
Cellulose [1]	43·0

[1] *Calculated on the dry stems.*

The stems were submitted to treatment with caustic soda under conditions similar to those used on a commercial scale for the production of paper pulp, with the following results :

Experiment.	Caustic soda used.		Conditions of boiling.		Parts of soda consumed per 100 parts of stems.	Yield of dry pulp expressed on stems as received.
	Parts per 100 parts of stems.	Parts per 100 parts of solution.	Time.	Temperature.		
			Hours.			*Per cent.*
A	6	1·2	5	140° C.	All soda consumed	42
B	16	4	5	140° C.	10·4	34
C	20	4	5	140° C.	12·8	33

The stems were easily convertible into pulp under the conditions employed in experiment A, but the product thus obtained could not be bleached. The more drastic conditions of experiments B and C gave unbleached pulps

of light brown colour, which yielded fairly strong opaque papers. In all cases the pulp showed a tendency to shrink on drying owing to the presence of a considerable amount of parenchyma. Under the conditions normally employed for the manufacture of paper pulp the pulps produced from these papyrus stems could only be bleached to a cream colour.

The results of this investigation indicate that these papyrus stems only furnish a moderate yield of pulp of fair quality, which contains a quantity of parenchyma, and is rather difficult to bleach. Pulp suitable for brown paper can be prepared from the stems by mild treatment, but only cream-coloured paper can be produced by treating the stems under more drastic conditions similar to those employed technically for the manufacture of pulp for the production of white paper.

The present sample of *Cyperus Papyrus* is inferior to the samples of *C. alopecuroides* from Egypt dealt with above, as it contains less cellulose and gives a lower yield of pulp. The pulp produced from it is generally similar in character to the pulp prepared under similar conditions from *C. alopecuroides*, but is rather darker in colour.

These stems of *Cyperus Papyrus* could not be remuneratively exported as a paper-making material, but might be utilised in Egypt for this purpose.

4. Papua

Lalang Grass

Lalang grass (*Imperata arundinacea*, Cyr.) from the Federated Malay States was examined at the Imperial Institute in 1917 (this Bulletin, 1918, **16**, 271), and for the purpose of comparison a sample of the grass from Papua was forwarded at the suggestion of the Imperial Institute in August 1918.

The sample consisted of a bale of brown grass of similar character to that from the Federated Malay States. In some parts of the bale the grass had begun to rot, probably owing to its having been packed in a wet condition, and on the whole the sample was in rather poor condition.

The grass was submitted to chemical examination with

the following results, which are shown in comparison with those obtained for the previous sample of the Malay grass :

	Present sample.	Sample from the Federated Malay States.
	Per cent.	*Per cent.*
Moisture	10·8	9·2
Ash[1]	8·1[2]	4·0
Cellulose[1]	54·5	56·0
Length of ultimate fibres .	0·3 to 4·1 mm., mostly 1·0 to 2·5 mm.	0·4 to 3·0 mm., mostly 1·0 to 2·0 mm.

[1] *Calculated on the dry grass.*
[2] *This large percentage of ash was apparently due to the presence of adherent earth on the root ends of the stems.*

The grass was tested as a paper-making material by treatment with caustic soda, under conditions similar to those used on a commercial scale, with the following results :

Experi-ment.	Caustic soda used.		Conditions of boiling.		Soda consumed per 100 parts of grass.	Yield of dry pulp expressed on the grass as received.
	Parts per 100 parts of grass.	Parts per 100 parts of solution.	Time.	Tempera-ture.		
			Hours.			*Per cent.*
A	10	2	5	140° C.	7·4	42
B	16	3	5	140° C.	9·0	40
C	20	4	5	140° C.	12·2	37

The following table shows the results furnished by the present sample of lalang grass, and by the previous sample from the Federated Malay States when treated under similar conditions :

Experi-ment.	Caustic soda used per 100 parts of grass.	Lalang grass from Papua.		Lalang grass from Federated Malay States.	
		Yield of un-bleached pulp.	Results of bleaching.	Yield of un-bleached pulp.	Results of bleaching.
		Per cent.		*Per cent.*	
A	10	42	Will not bleach	43	Bleaches to cream colour.
B	16	40	Bleaches to pale cream	41	Bleaches to pale cream.
C	20	37	Bleaches to almost white, but not so good as the pulp from Federated Malay States sample.	40	Bleaches to white.

It will be seen that the yields of unbleached pulp obtained from this lalang grass from Papua are slightly lower than those from the Malay grass when treated under similar conditions.

The papers yielded by the pulps prepared from the present sample are opaque, and do not shrink on drying. On the whole they are of similar quality to those obtained from the Malay grass, but the colour of the bleached papers is inferior, especially in experiment A. This inferiority, and also the slightly lower yield of pulp, is possibly to be attributed to the rather poor condition of the sample. It is probable that lalang grass from Papua, if in good condition, would yield results equal to those given by the grass from the Federated Malay States.

The results of this investigation of lalang grass from Papua confirm those obtained previously at the Imperial Institute with a sample from the Federated Malay States, and indicate that this grass would be a useful paper-making material.

Lalang grass compares favourably for this purpose with Algerian esparto grass, but appears to require slightly more drastic treatment than the latter if it is desired to obtain pulp suitable for the manufacture of white paper. Unbleached pulp of good quality suitable for the production of strong wrapping paper or cardboard can however be prepared from lalang grass by comparatively mild treatment.

As a paper-making material lalang grass would be worth about the same price as Algerian esparto grass, which sold at £3 10*s.* to £4 2*s.* 6*d.* in the United Kingdom before the war (July 1914). In view of the bulky nature of the grass and the consequent heavy freight, it would not be remunerative to export lalang grass from Papua to this country, but it should be possible to utilise it in Australia for paper making.

5. St. Helena

Thatching Grass

A sample of so-called "thatching grass" was received from St. Helena in October 1917. The botanical identity of the grass was not stated.

The sample consisted of pale straw-coloured reed-like stems and leaves. The stems measured up to $\frac{5}{16}$ in. in diameter, and has been cut into lengths of about 20 in.

The grass was submitted to chemical examination at the Imperial Institute with the following results :

	Per cent.
Moisture	9·7
Ash[1]	8·2
Cellulose[1]	54·5
Length of ultimate fibres	Up to 4·4 mm., mostly from 2·0 to 3·0 mm.

[1] *Calculated on the dry grass.*

In order to determine its suitability for use as a paper-making material, the grass was treated with varying amounts of caustic soda, under conditions similar to those used for the production of pulp on a commercial scale, and the results are shown in the following table :

Experiment.	Caustic soda used.		Conditions of boiling.		Soda consumed per 100 parts of grass.	Yield of dry pulp expressed on grass as received.
	Parts per 100 parts of grass.	Parts per 100 parts of solution.	Time.	Temperature.		
			Hours.			*Per cent.*
A	13	4	4½	140° C.	9·0	42
B	16	4	4½	140° C.	10·0	39
C	20	4	4½	140° C.	10·5	38

The results of these experiments show that the grass gives a fairly good yield of long-fibred pulp, producing a strong, tough, opaque paper which does not shrink appreciably on drying. The pulps did not bleach easily, but that produced under the conditions of experiment C bleached to a fairly satisfactory colour.

This "thatching grass" could be utilised as a paper-making material, but its export from St. Helena to Europe would not be remunerative as it would have to compete with esparto grass, which gives a higher yield of better pulp, and was obtainable in the United Kingdom at £5 per ton or less under pre-war conditions.

An alternative plan for the commercial utilisation of such grasses is to convert the material into pulp in the country of origin, but this would be scarcely feasible in St. Helena, as the process requires the installation of

expensive plant and considerable supplies of chemicals which would have to be imported into the island. Moreover it is doubtful whether the supply of the grass available in St. Helena would be sufficient to maintain the industry for any length of time.

A NEW SOURCE OF TURPENTINE AND ROSIN IN INDIA

In a previous number of this Bulletin (1915, **13**, 351) an account was given of the results of investigation at the Imperial Institute of the turpentine oil and rosin obtained by the distillation of the gum-oleo-resin of *Boswellia serrata.* Since then further samples of these products, as well as samples of gum derived from the same source, have been examined, and their commercial value and uses investigated. An enquiry has also been carried out in India at the Forest Research Institute, Dehra Dun, and a report on the methods of tapping the trees, the preparation of the products, their chemistry, commercial value and industrial uses, is incorporated in a paper entitled "Note on the preparation of Turpentine, Rosin and Gum, from *Boswellia serrata* (Roxb.) gum-oleo-resin," by R. S. Pearson, F.L.S., I.F.S., and Puran Singh, F.C.S., published in *Indian Forest Records* (1918, **6**, 303). A summary of the information given in this paper, and the results of examination of the products at the Imperial Institute, are given in the present article.

Description and Distribution of the Tree

Boswellia serrata, Roxb., is a moderate-sized tree, belonging to the natural order Burseraceæ. A number of important resins are obtained from plants in this order, including African olibanum or frankincense, derived from *Boswellia Carteri,* Birdw., and *B. Frereana,* Birdw., myrrh from *Balsamodendron* spp., bdelliums from *Commiphora* spp., manila elemi from *Canarium* spp., West Indian elemi from *Dacroydes hexandra,* Griseb., and American elemi from *Bursera gummifera,* Linn.

According to some authors there are two forms of the tree, *B. serrata* proper, which occurs in the intermediate

northern and southern dry zones, and *B. serrata* var. *glabra*, Hook. f., a native of North-West India, which Roxburgh regards as a distinct species, under the name *B. glaber*.

Pearson and Puran Singh state that *B. serrata* is found from the Sutlej extending eastwards to Nepal, on the outer slopes of the Umballa and Saharanpur Siwaliks. It is common throughout Rajputana, Bihar and Orissa, in the Circars, the Central Provinces, Khandesh, especially on the slopes of the Satpuras, in the Deccan and Carnatic, but it is not found in Assam. It is rare in Burma, but according to *Agricultural Ledger* (1900, No. 10, p. 101) it is said to attain a height of 100–120 ft. with a girth up to 10 ft. and over in the Pegu Forest Circle. Elsewhere in India it only attains a height of about 40–60 ft., with a girth of 3–5 ft. The tree is often the dominant plant on hot rocky hillsides, and is frequently the forerunner of better forests as soon as protection from fire and grazing is introduced.

Information has been collected from certain localities as to the number of trees available for tapping. From the figures given the tree appears to be most abundant in parts of the Central Provinces; in the Nagpur-Wardha Division there are approximately 9,000,000 available in the East Pench Range and 2,500,000 in the West Pench Range; whilst there are 5,000,000 in the Chandni Range, 3,500,000 in the Burhanpur Range, and 1,250,000 in the Khandwa Range of the Nimar Division. The Conservator of Forests, Berar Circle, however, expresses the opinion that the last three estimates are high, and should be treated with caution. In the North, East and West Khandesh Divisions of Bombay Presidency also there are large numbers of the tree. The total number available for tapping in selected areas of these three divisions amounts to nearly 12,000,000, of which more than half occur in the Shirpur Range of North Khandesh.

Method of Tapping

Difficulty having been experienced in ascertaining the best method of tapping *B. serrata*, experiments were undertaken in widely separated districts.

In the Nimar Division, Central Provinces, 1,023 trees were tapped from January 21 to February 23, the average yield of gum-resin per tree being as follows :

Girth of tree.	Average yield.
	oz.
24–30 in.	0·9
30–36 in.	1·3
36 in. and over	1·9

In the areas tapped there were eight trees per acre with a girth of 24–30 in., seven trees 30–36 in., and eight trees 36 in. and over. For a working season of five months, the yield per acre would be :

Girth of tree.	Yield per acre.
	lb.
24–30 in.	2·27
30–36 in.	2·95
36 in. and over	3·58
Total	8·80

The trees were tapped by shaving off a girdle of bark one foot broad to a depth of about half the thickness of the bark, and "freshing" at definite intervals. It was found that the gum-resin should be collected and the cuts "freshed" at least every fourth day to obtain the highest yield of gum-resin. As a general rule, old trees with black bark, dwarfed and suppressed trees, and trees with a short boll, yielded no gum-resin, whilst this was the case also with a large number of healthy trees of small girth. On the other hand all sound and vigorous trees of 30 in. girth and over, all trees attacked by borers or otherwise diseased, and generally all hollow trees, yielded well.

Further experiments conducted during the rainy season in Nimar gave better results as regards yield than those referred to above, which were obtained during the dry season. The average yields of gum-resin per tree in the later experiments were 5·0 oz. in July and 7·6 oz. from other trees tapped in August. In this case, however, the gum-resin had absorbed water from the rain, which rendered it difficult to deal with subsequently in the solvent still, where the gum is separated from the rosin and turpentine.

Two series of tapping experiments were carried out in

the North Khandesh Division of the Bombay Presidency. The method of tapping adopted was to remove a band of bark one foot broad all round the trunk, and nearly as deep as the cambium, at a height of 3 ft. 6 in. from the ground. The gum-resin was collected and the tapping wounds "freshed" every five days.

Ninety trees 24 in. in girth and over produced, as the result of nine collections, a total average yield of 1·07 oz. per tree, during the months of June and July. Another series of experiments with ninety trees was conducted over a period of seven months (December to June). In this case the "freshing" consisted of removing a thin layer of bark from the upper half of the cut and a further ½ in. or so of bark from above the old wound. In forty-five of the trees the bark was bruised above the "freshed" wounds, but it was found that this reduced the yield enormously. The following yields of gum-resin were obtained from the unbruised trees.

Girth.	Number of trees.	Dec. 1916.	Jan. 1917.	Feb. 1917.	Mar. 1917.	April. 1917.	May. 1917.	June. 1917.	Total.	Average per tree.
		oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.
24–30 in. . .	15	33·6	30·0	50·4	67·6	46·4	41·2	5·6	274·8	18·3
30–36 in. . .	15	38·4	64·0	63·2	57·6	69·6	53·6	15·2	361·6	24·1
Above 36 in. .	15	129·6	138·0	171·2	209·6	140·4	169·2	21·6	679·6	65·3
Total . .		201·6	232·0	284·8	334·8	256·4	264·0	42·4	1,316·0	35·9

The above results show that the largest trees give the greatest yield of gum-resin and that the flow increases up to a certain point as tapping is continued. The flow reached its maximum at about the twentieth time of "freshing."

The low yields obtained in June in both series of experiments in North Khandesh are attributed to the fact that the rainy season commences in that month. Further drawbacks to the industry being carried on during the rainy season are the difficulty of moving about the forests at that period, and the lack of labour in the forests owing to the high wages paid for agricultural work at that time of year.

It was noticed in the North Khandesh experiments that trees with thick bark yield more gum-resin than those with thin bark, whilst large trees yield much more per

square inch of wound surface than small trees, and it is doubtful whether it will pay to tap the latter.

Tapping operations have been carried out for generations by the villagers in the Sheopur Range in the Gwalior State, and the results prove conclusively that the tapping of *B. serrata* can be carried out successfully on a commercial scale. It is estimated that the natives, who work generally in pairs, can collect ten to twelve maunds (823 to 987 lb.) per pair per season. The method of tapping is to make a preliminary blaze about 4 in. wide and about 4 ft. from the ground, towards the end of the rainy season. About a month later the wound is "freshed" by cutting off a thin shaving of bark all round the stem, over half the depth of the old blaze, and taking in 2 in. of new bark on the upper edge of the original wound. A similar "freshing" is made at intervals of about a week until the end of March, when collection stops. The yield of gum-resin from the first "freshing" is small, but it increases until the fourth "freshing," after which it is said to remain practically constant. No very definite information was obtained as to the yield per tree by this method of tapping, but twenty average trees which had been once "freshed" gave a total yield of 10 oz., and twenty others which had been twice "freshed" gave 28 oz., whilst two abnormal trees, twice "freshed," yielded 22 oz.

As regards the effect of tapping on the trees it was found that out of the 1,023 trees tapped in the Nimar experiments (see p. 161), 993 had, for all intents and purposes, completely recovered when they were inspected three years after tapping had taken place; ten trees were badly damaged, and twenty were dead, but all the latter were old, smothered with the parasite Loranthus, and severely attacked by insects. The most definite proof is available from Gwalior that no serious damage is done to the trees by tapping, provided that the operation is confined to a band 8–12 in. wide, and subsequently "freshed." In that locality, the trees had been tapped in this way year after year for generations, and not a single tree was found to have been killed.

From the experiments conducted in Nimar and Khan-

desh, and also from the corroborative evidence obtained from Gwalior, the following conclusions were drawn as to the best methods of tapping *B. serrata* gum-resin :

(*a*) The method of tapping should consist of shaving off a thin band of bark about 6 in. broad, 2 ft. to 2 ft. 6 in. from the base of the tree.

(*b*) Tapping should generally be commenced in November, and should stop before the break of the monsoon.

(*c*) "Freshing" should be undertaken every fourth or fifth day, and should consist in removing a thin shaving of ½ in. to 1 in. of new bark from the upper edge of the original belt, and carrying down the "freshing" to within an inch of the lower edge.

(*d*) Tapping of trees below 30 in. in girth is not advocated.

(*e*) Individual trees which yield little gum-resin after the initial tapping, and after the first "freshing," should be excluded from the operations.

(*f*) The effect of tapping on the trees need cause no serious apprehension.

Taking into consideration estimates given by various forest officers, the cost of collection of the gum-resin is considered to be probably about 5 rupees per maund (= about 9*s*. per cwt). It is estimated that the total number of trees available for tapping in various localities would produce about 27,000,000 lb. of gum-resin per annum. This figure is based on the average yield per tree obtained in the North Khandesh experiments, and on the assumption that each tree would be tapped every third year.

Composition of Boswellia serrata *Gum-resin*

From the results of analyses of eight samples collected by the Forest Officer at Khandesh during 1917, the average composition of the gum-resin may be taken to be as follows :

	Per cent.
Moisture	10–11
Turpentine oil	8–9
Rosin	55–57
Gum	20–23
Insoluble matter	4–5

Preparation of Boswellia serrata *Turpentine Oil, Rosin and Gum*

Messrs. Pearson and Puran Singh give a rough design of a plant proposed for the preparation of Boswellia products. The process is based on experiments conducted at the Forest Research Institute, Dehra Dun, but the plant is purely of an experimental nature, as certain factors remain to be determined owing to the tests having been made in an adapted still. The plant consists of a solvent extractor and a steam still, both fitted with condensers; two settling tanks; a solvent storage tank; turpentine, solvent, and resin receivers; and a tank for collecting the sludge.

Two methods of extraction are suggested:

(1) *Solvent extraction followed by steam distillation.*—The solvents recommended are light petroleum (boiling point 80°–110° C.) or trichlorethylene (boiling point 88° C.). The latter solvent possesses the advantage that it is non-inflammable, and also that it is more readily expelled from the gum-resin, but it is not so easily recovered. The solvent dissolves out all the constituents except the gum and woody impurities. After allowing impurities to settle out, the solvent solution is run into the still, and the solvent gradually distilled off with the help of the steam jacket. Steam is afterwards passed in, and the turpentine oil thus distilled off. The rosin can finally be run off in a molten state into barrels. The residual gum retains about an equal weight of solvent, the recovery of which is effected by treatment with superheated steam. This method possesses the disadvantage that the turpentine oil retains traces of the solvent which alters its constants.

(2) *Steam distillation followed by solvent extraction.*—The turpentine oil is first distilled off the crude material by superheated steam at 120°–130° C. By this method no water condensation takes place in the still, thus obviating the absorption of water by the gum. The residual mixture of gum and rosin is afterwards separated by treatment with the solvent as before. The advantages of this second method are that the turpentine is free from

the solvent, and that the gum and rosin being in a dry state after the removal of the turpentine, are readily acted upon by the solvent.

Character, Uses and Commercial Value of the Turpentine Oil of Boswellia serrata

Two samples of turpentine oil prepared from the gum-resin of *Boswellia serrata* have been examined at the Imperial Institute. The results of examination of a sample received in 1914 have already been published in this BULLETIN (1915, **13**, 352), but a summary of the results is given below in comparison with those obtained in the case of a sample received in 1917.

The earlier sample consisted of rectified oil with a slight greenish-yellow tinge and a sweet agreeable odour. The second sample was a pale yellow oil, with an agreeable odour very similar to that of the previous one.

The two samples of oil were submitted to chemical examination at the Imperial Institute with the results shown in the table below. The constants obtained in India in the case of a sample of re-distilled oil, from which the fraction of high boiling residue had been eliminated, prepared by steam distillation on a large scale at the Forest Research Institute, Dehra Dun, and the usual constants of commercial American and French turpentine oils are included for comparison.

	Results obtained at the Imperial Institute.		Results obtained in India.	Commercial turpentine oil.	
	Sample No. 1.	Sample No. 2.	Re-distilled oil.	American.	French.
Specific gravity at 15/15° C.	0·8446	0·8523	0·8371 (at 22° C.)	0·858 to 0·877	0·865 to 0·875
Optical rotation	+31° 24′	+25° 57′	+32° 30′	+9° 30′ to +14° 17′ (rarely slightly lævo-rotatory)	−29° to −33°
Acid value	Nil	Nil	—	—	—
Ester value before acetylation	2·6	3·0	—	—	—
Ester value after acetylation	36·4	54·3	—	—	—

The results of fractional distillation were as follows :

Results obtained at the Imperial Institute

	Sample No. 1. Per cent.	Sample No. 2. Per cent.
Fraction boiling at :		
153°–160° C.	89	56
160°–170° C.	11[1]	24
170°–180° C. and above		20

[1] *All between* 160° *and* 180° *C.*

Results obtained in India

	Original oil. Per cent.		Re-distilled oil. Per cent.
Below 160° C.	50·0	Below 155° C.	87
160°–167° C.	17·5	155°–160° C.	8
167°–180° C.	11·0	Above 160° C.	5
Above 180° C.	22·5		

In the case of sample No. 1 the fraction boiling at 153° to 160° C. was re-distilled and practically the whole passed over at 155° C.

For comparison with the above figures it may be stated that 85 per cent. of American turpentine oil usually distils between 155° and 163° C., and 85 to 90 per cent. of French oil between 155° and 165° C.

It was found that the Boswellia turpentine oil readily dissolved resins such as colophony, dammar, sandarac and soft copal, but varnishes prepared at the Imperial Institute in this way with both samples of oil were less lustrous and quicker in drying than varnish prepared with ordinary commercial turpentine under the same conditions.

The two samples of oil received at the Imperial Institute were submitted to various firms for technical trials and commercial valuation with the following results :

Sample No. 1.—Specimens of this oil, which as already mentioned consisted of rectified oil, were submitted to several turpentine oil merchants and distillers, and to varnish manufacturers. The general opinion expressed was (1) that the oil is of very good quality and closely resembles American turpentine oil, except as regards the smell, which is regarded as peculiar though not unpleasant, and (2) that the Boswellia oil could be successfully employed like ordinary turpentine oil in the manufacture of varnishes.

All the firms consulted thought that the Boswellia oil would be readily saleable in the United Kingdom. One firm stated that its commercial value should be approximately equal to that of American turpentine oil, though the difference in smell might constitute a slight drawback. Another firm considered that the oil would find a ready market in the United Kingdom if it could be sold at about 25 per cent. under the price of American turpentine oil, and a third valued it at about 30*s*. per cwt., with American turpentine oil at 37*s*. per cwt.

Sample No. 2.—This was submitted to two firms of varnish manufacturers.

The first firm stated that they had prepared for comparison two varnishes, one with genuine American turpentine oil, and the other with the Boswellia turpentine oil, the remaining constituents in each case being the same, and had found that the Boswellia turpentine oil rendered the varnish slightly dull, whereas the varnish made with American turpentine oil remained bright. Equivalent quantities of Boswellia turpentine oil and American turpentine oil gave varnishes of different viscosity, that made with Boswellia turpentine being considerably thinner. The drying and "face" of the finished varnishes were however practically identical.

The firm considered that as a substitute for American turpentine oil the Boswellia oil would probably be placed between French or Spanish and Swedish or Russian turpentine, but they were unable to assign a definite commercial value to it under present conditions.

The second firm reported as the result of practical trials that this turpentine oil has a tendency to accelerate the drying of varnishes, but that it detracts from their brilliancy and durability for exterior work. They stated that there is apparently no reason why Boswellia turpentine oil should not be utilised in the varnish trade.

Sample No. 2 contained a much larger percentage of the higher-boiling constituents than the first sample, but nevertheless the varnish prepared with it dries rather quicker than that made with ordinary commercial turpentine oil. The inclusion of the higher-boiling fractions does not appear to have any adverse effect on the

quality of the varnish, so that it would seem unnecessary to remove these fractions in preparing the Boswellia oil for commercial use. The best rule on this point would probably be to make the product agree in range of boiling point with commercial American turpentine.

Favourable results were also obtained in the case of samples of oil submitted for technical trial in India. One report stated that it is suitable for paint-making, paint prepared with it drying in under twenty-four hours, whilst another firm stated that as regards volatility the oil is excellent and better in this respect than any of the samples of the oil of *Pinus longifolia* prepared in India which had been submitted to them.

There seems to be little doubt that this Boswellia turpentine oil could be successfully utilised for varnish-making in place of ordinary turpentine oil, but it is not possible to state its exact commercial value until the product has been tried on a considerable scale.

Character, Uses and Commercial Value of the Rosin of Boswellia serrata

A report on two samples of Boswellia rosin, examined at the Imperial Institute in 1914, was published in the earlier article in this BULLETIN (*loc. cit.*, p. 354). A summary of these results is given in the following pages, together with those obtained in an investigation of three further samples received in 1916 and 1917.

Sample No. 1 was prepared by steam-distillation, and consisted of dark brown, very brittle resin, with a vitreous fracture. The resin resembled colophony in odour, and was practically tasteless.

Sample No. 2 was obtained by heating the resin in a still over a gentle fire. It consisted of dark, greenish-black, very brittle resin, with a vitreous fracture. The resin had a slight " burnt " odour, but no taste.

Sample No. 3 was prepared in an extractor with light petroleum as a solvent. It consisted of golden-brown, brittle, transparent resin ; its colour and appearance were approximately those of grade " G " colophony.

Sample No. 4 was described as "first instalment of Boswellia rosin, slightly frothy, made in copper," and consisted of dark brown, very brittle rosin with a vitreous fracture; in thin layers it was transparent.

Sample No. 5 was described as "third instalment clear samples, fully heated though underboiled." It resembled sample No. 4 in every respect, except that in colour it was dark greenish-brown.

The results of the chemical examination of the five samples received at the Imperial Institute are shown in the following table, which includes for comparison the results obtained in India for two samples of Boswellia rosin prepared respectively with light petroleum and Boswellia turpentine as solvents.

	Samples examined at the Imperial Institute.					Samples examined in India.	
	1	2	3	4	5	Prepared with light petroleum.	Prepared with Boswellia turpentine.
Moisture *per cent.*	0·7	0·9	0·7	0·8	1·1	—	—
Ash . *per cent.*	0·5	0·4	0·03	0·3	0·2	—	—
Melting point:							
Rosin softens at .	72° C.	56° C.	68° C.	71° C.	65° C.	—	—
Rosin melts at .	—	—	—	78° C.	73° C.	—	—
Acid value . .	51·5	25·0	55·1	52·4	50·8	43·71	42·51
Saponification value	92·0	66·0	90·2	87·8	75·6	89·66	88·40
Iodine value, *per cent.*	70·0	96·0	—	64·6	76·2	97·10	98·20
Specific gravity .	1·082 (at 20/20° C.)	1·050 (at 20/20° C.)	—	1·077 (at 18/18° C.)	1·059 (at 18/18° C.)	—	1·058

It will be seen that the constants of Sample No. 2 differ from those of the other samples, and it would appear that this sample was abnormal.

The samples of rosin examined at the Imperial Institute were completely soluble in alcohol, ether, chloroform, benzene and turpentine oil, with the exception that Sample No. 2 was only partly soluble in alcohol.

Varnish trials made at the Imperial Institute with the rosin gave satisfactory results. In the case of Samples Nos. 4 and 5 the varnishes used consisted of 1 part of the rosin and 1 to 2 parts of turpentine oil. These varnishes, when applied to sized wood, dried rather slowly to a clear, bright, hard coat, which adhered firmly and did not crack.

Varnishes prepared with 1 part of alcohol to 1 part of the rosins gave the same result.

Boswellia rosin was found to be not completely soluble in sodium carbonate solution, even on prolonged boiling, and it could not therefore be used as a substitute for colophony in making rosin soap or rosin size.

Enquiries were made by the Imperial Institute as to the commercial value of the rosin and samples were submitted to firms for technical trial. A firm of importers valued the rosin at about £20 per ton in London (July 1916). A firm of spirit varnish manufacturers described it as equal in all respects to American rosin, and quite suitable for making certain qualities of spirit varnishes. They regarded it as about equal to grade "G" of American rosin, the market price of which was £21 to £22 per ton in London (July 1916). The normal value of this grade of rosin before the war was about £14 per ton. Another firm of varnish manufacturers carried out experiments to ascertain whether the rosin could be used to replace American rosin in the manufacture of the cheaper varieties of varnish. The results were very satisfactory and indicated that the Boswellia rosin would be an excellent substitute for American rosin for this purpose. This firm stated that in their opinion the value of the Boswellia rosin would be the same as that of the American product, *i.e.* 63*s.* per cwt. in the United Kingdom (September 1918).

Equally satisfactory reports were furnished by firms in India to whom samples were submitted by the Forest Economist, and it seems quite clear that Boswellia rosin can be used by varnish makers in place of American rosin.

Character and Uses of the Gum of Boswellia serrata

Three samples of Boswellia gum were received at the Imperial Institute in May 1916. They all appeared to be composed of the same material and to differ only in the size of the pieces composing the samples. Sample No. 1 consisted of small tears and fragments, No. 2 of small fragments, and No. 3 of very small fragments and dust, with some sand and dirt.

The three samples were analysed with the following results :

	No. 1. Per cent.	No. 2. Per cent.	No. 3. Per cent.
Moisture	14·4	13·9	12·4
Ash	3·0	3·5	9·3[1]
Matter soluble in 95 per cent. alcohol	23·6	20·7	16·9
,, ,, ,, ether	20·9	17·3	11·6
,, ,, ,, cold water	42·9	48·5	39·2
Specific gravity of a 10 per cent solution at 15/15° C.	1·026	1·023	1·022
Viscosity of a 10 per cent. solution at 22° C.[2]	3·6	3·3	2·8

[1] *The average of five determinations which varied from* 7·3 *to* 10·8 *per cent.; owing to the presence of heavy sandy matter it was difficult to obtain a really average sample of the material.*

[2] *As compared with* 1 *for water and* 6·5 *for soft Kordofan gum,* 7·1 *for Sudan Talh gum, and* 12·0 *for hard Kordofan gum, determined under the same conditions.*

These results are compared in the following table with those obtained in India by the Chemical Adviser at the Forest Research Institute, Dehra Dun, the Imperial Institute results being given under the heading A, and those of the Chemical Adviser under the heading B. In order to eliminate discrepancies due to variation in moisture, the results have been expressed in all cases on the dry materials.

	Sample No. 1.		Sample No. 2.		Sample No. 3.	
	A	B	A	B	A	B
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Ash	3·5	3·4	4·1	4·0	10·6	7·1
Resin (matter soluble in 95 per cent. alcohol)	27·6	not given	24·0	10·2	19·3	21·2
Soluble gum (matter soluble in water)	50·1	not given	56·3	not given	44·8	not given
Insoluble gum and dirt (exclusive of ash)	18·8	—	15·6	—	25·3	—
Matter soluble in ether (dry and free from alcohol)	24·4	9·0	20·1	9·4, 8·3	13·2	18·3, 19·4

It will be seen from these figures that the results obtained at the Imperial Institute for matter soluble in alcohol and in ether (which for either solvent may be regarded as resin) do not agree with those found by the

Chemical Adviser, and the latter points out in the paper referred to at the beginning of this article that the differences are due to the lack of uniformity in the samples.

With a view to ascertaining the suitability of the gum for sizing purposes the following attempts were made at the Imperial Institute to obtain " jellies " from the gum:

(*a*) One part of the gum was allowed to stand overnight with 2 parts of water, and was then heated for 1 hour in a boiling-water bath and allowed to cool. Only a pasty mass was obtained.

(*b*) One part of the gum was allowed to stand overnight with 10 parts of water, after which it was warmed on a water bath and allowed to cool. The liquor was freed from solid matter by being squeezed through calico and the filtrate was concentrated on a boiling-water bath, but no jelly was obtained.

(*c*) One part of gum was heated under pressure with 5 parts of water at 133° C. for 1½ hour, but yielded only a thin, non-homogeneous paste of a brown colour.

From these experiments it appeared that this gum is much inferior to ordinary gum for use as a sizing material, but it was nevertheless submitted to one of the most important British calico-printing firms for trial as a sizing and finishing material for textiles. Their technical experts reported as follows:

(*a*) An attempt was made to obtain a solution in water at a strength of 4 : 10, but even with prolonged heating the result was merely a rough pasty mass.

(*b*) The gum was then heated in a closed bottle for an hour under a steam pressure of 6–10 lb. This also failed to produce a smooth paste, though with undoubtedly better results as regard thickness. The material, however, was not sufficiently homogeneous to serve as a thickener or as a sizing agent.

(*c*) It was found that a strong solution of caustic soda dissolved the gum, but there was no " body " in the product, and subsequent neutralisation of the alkali with acid reprecipitated the gum.

(*d*) The gum was found to be but little affected by weak solutions of caustic soda, sodium carbonate or borax, and acetic acid was also without solvent action.

As a result of these trials the conclusion arrived at by the experts was that the "insolubility" of this gum (*i.e.* the presence of resin and gum insoluble in water) would prevent its employment for the purpose of sizing and finishing textiles.

A further sample of the gum was forwarded to the Imperial Institute in December 1917. It consisted of a finely ground, light buff powder with a pleasant aromatic odour.

The gum was submitted to chemical examination with the results shown in the following table, which also includes the results obtained at the Forest Research Institute in the case of a sample completely freed from resin and insoluble woody matter.

	Sample examined at the Imperial Institute.	Sample examined in India.
	Per cent.	*Per cent.*
Moisture	13·1	18·75
Ash	3·5	3·28
Water-soluble matter	73·7	74·20 [1] 74·35 [2]
Alcohol-soluble matter	2·7	not given
Viscosity of 10 per cent. solution at 22° C.[3]	5·4	—
Specific gravity of 10 per cent. solution at 20/20° C.	1·031	—

[1] *In 5 parts of water.*
[2] *Portion dissolved in 60 parts of water by repeated extraction.*
[3] *Compared with 1 for water and 6·5 to 7·0 for gum acacia under the same conditions.*

When dissolved in water the sample examined at the Imperial Institute formed a thick, cloudy, colloidal solution.

It will be seen from the above results that the later sample of Boswellia gum is superior in composition to the three previously examined, as it contains much less resin (alcohol-soluble matter) and is much more soluble in water. The viscosity of a 10 per cent. solution of the gum is also greater than in the case of the earlier specimens. Even this sample, however, does not compare favourably with gum arabic. A 10 per cent. solution in water was cloudy, and had a lower viscosity than a gum arabic solution of the same strength; it also darkened when heated and deposited solid matter on standing. The

solution was fairly adhesive, but inferior to gum arabic in this respect. The 10 per cent. solution did not form a jelly, and was much more liquid than a 5 per cent. starch jelly.

The sample was too small to permit of any technical trials being made, but it seems unlikely that the material could be used to any extent as a substitute for gum arabic except possibly locally in India.

Under-extracted Gum

Boswellia gum containing 30 to 40 per cent. resin has been tried in India as a paper size. A cellulose expert who examined a sample of this material stated that the sizing effect he obtained was sufficiently good to warrant a commercial trial being made.

A sample of this gum was subsequently submitted to an Indian firm for trial under practical working conditions, with the following results : Two experiments were undertaken with a sizing solution made up by dissolving 100 lb. gum with 3 per cent. of 77 per cent. caustic soda in 90 gallons of water. In the first experiment 500 lb. of "stuff" were beaten with 40½ gallons of the sizing solution, 25½ lb. of alum were then added ; the quantities represented 9 per cent. of gum and 5·1 per cent. of alum. The sizing results in the finished paper were only considered fair. In the second experiment the quantities used represented 10 per cent. of gum and 4·6 per cent. of alum. The sizing results were in this case slightly better. In each experiment the wet pulp gave a more or less acid reaction. The firm stated that further trials would be necessary before any general conclusion could be drawn as to the value of the material for sizing paper, but they were of opinion that the large percentage of resin present might cause trouble in the machine, and produce early yellowing and rapid deterioration in the case of white paper.

Preparation of Boswellia Products for the Market

The following recommendations are made by Messrs. Pearson and Puran Singh regarding the methods of preparing Boswellia products for the market.

Turpentine Oil.—The authors agree with the view expressed in the earlier report made by the Imperial Institute (this BULLETIN, 1915, **13**, 353) that the oil should be marketed in the crude state, and that it is inadvisable to rectify it (see also p. 169).

Rosin.—Overheating should be avoided in the preparation of the rosin, for this, in addition to darkening its colour, reduces its "strength." Care must also be taken to free it from fine particles of dirt by allowing sufficient time for settling in the tanks when the rosin is in a state of solution in the solvent. It seems impossible to remove the dirt at any other stage of working.

Gum.—The refinement of the gum on a large scale has been found to be difficult, and it is recommended that it be placed on the market in the form of "flour," as is done in the case of similar gums. In the process of grinding and sifting particles of bark are removed.

Under-extracted Gum.—If further trial should demonstrate that this product can be used as a subsidiary sizing material, it would be quite easy to stop the extraction of the gum-resin at a fixed point in order to produce the mixed substance.

Cost of Manufacture of Boswellia Products

In the form of a profit and loss account, Messrs. Pearson and Puran Singh have tabulated a rough estimate of the cost of preparing 77 gallons of turpentine oil, 55 maunds (= about 2 tons) of rosin, and 22 maunds (= about 16 cwts.) of gum, from 100 maunds (= about 3⅝ tons) of the crude *Boswellia serrata* gum-resin. They estimate the total cost of collecting, distilling, interest on working capital, depreciation on plant, packing, insurance, etc., at 780 rupees (= £52). The values of the receipts are based on pre-war rates; the turpentine oil at 2½ rupees (=3*s.* 4*d.*) per gallon, the rosin at 10 rupees per maund (= 18*s.* 2*d.* per cwt.), the gum at 5 rupees per maund (= 9*s.* 1*d.* per cwt.), making a total of 852½ rupees (=£56 16*s.* 8*d.*). This would represent a profit of 72½ rupees per 100 maunds of gum-resin (=£4 16*s.* 8*d.* per 8,228 lb., or nearly 1*s.* 4*d.* per cwt.).

The authors state that it will be necessary to confirm this estimated cost of manufacture in a single unit plant, before carrying out operations on a large scale; that there seemed no question of doubt as to finding a ready market for the turpentine and rosin, but that it was rather difficult to predict the market value of the gum, which, however, should sell readily at the above low price given in the estimate.

The above investigation has shown that *Boswellia serrata* gum-resin, which has hitherto been employed in India to a small extent chiefly as a substitute for *B. Carteri*, and *B. Frereana* in the preparation of incense, is capable of furnishing products of considerable commercial importance, and it seems probable that their preparation will constitute a profitable industry.

VARIETIES OF COFFEE FROM TRINIDAD, UGANDA AND SUDAN

1. Trinidad

A sample of coffee, stated to have been derived from *Coffea excelsa*, was received in December 1917. According to the *Bulletin of the Department of Agriculture, Trinidad and Tobago* (1918, **17**, 62), this species of coffee, which occurs wild in the French Congo, was introduced into Trinidad in 1905 or 1906. Plants raised from seed at the St. Clair Experiment Station, Port-of-Spain, at that time, have done well, and in 1916 and 1917 they fruited heavily. The yield from twenty-three trees in the latter year was 205 lb. or nearly 9 lb. per tree. This species has done much better at the Station than *C. robusta*, and can apparently withstand very adverse conditions. Planters in Trinidad are now giving their attention to this form of coffee, 74 lb. of seed and 718 plants being sold from the Experiment Station in 1917, and 1 lb. of seed and 1,991 plants in 1918, whilst 9,000 plants in stock were already booked up.

The sample received at the Imperial Institute consisted of beans freed from the parchment and skin. The

beans were of greyish-yellow colour and varied considerably in size. The general shape of the beans was oval with one flat side, but many were rounded.

The sample was in good condition, but contained a few damaged beans.

The coffee was examined at the Imperial Institute with the following results:

	Per cent.
Moisture	8·5
Caffeine	1·20
Total nitrogen	2·18
Ash	3·2
Average weight of a single bean	0·16 gram.
Number of beans required to fill a 50 cc. cylinder	204

The results of the chemical examination show that the coffee is of normal composition.

A firm of brokers to whom a sample of the coffee was submitted regarded the coffee as of the Robusta variety mixed with Arabica sorts. They described it as dull and dingy, but expressed the opinion that with greater care in preparation, the appearance and quality could be much improved. The firm valued the coffee at 80*s.* per cwt. in London, adding that the prices of Robusta coffee generally fluctuate with those of coffees from Brazil.

A second firm of brokers also considered the sample to represent a Robusta coffee, of hard bean and fair size. They regarded the appearance of the raw beans as attractive, but distinctly dull. The coffee gave a very dull "roast" and the liquor closely resembled that of Liberian coffee, which would make it unattractive for the British trade. In spite however of these drawbacks the firm estimated the value of the coffee at about 75*s.* per cwt. in London (May 1918), adding that in normal times there would be a good market for such coffee for the export trade from the United Kingdom. The prices for this class of coffee were at the time from 10*s.* to 15*s.* per cwt. above the pre-war values.

For comparison with the above valuations the following quotations for Robusta and Liberian coffee in the London market on the same date (May 1918) may be given:

	Per cwt.
Robusta coffee, plantation	70s.–80s.
Liberian coffee:	
East Indian	75s.–85s.
African (fair)	60s.–65s.
Malay	80s.–85s.
Java and Sumatra	75s.–90s.
Brazilian Santos:	
Superior	74s.–75s.
Prime	75s.–76s.
Extra	77s.–78s.

There is little doubt that coffee from *C. excelsa* as represented by this sample would be readily saleable in the London market under normal conditions at prices similar to those ruling for Liberian and Robusta coffees. The Acting Director of Agriculture in forwarding the sample stated that *C. excelsa* thrives better than other varieties under certain conditions of climate and soil, and its cultivation in Trinidad may therefore deserve consideration.

2. Uganda

Reference has already been made in this Bulletin (1914, **12**, 242; 1916, **14**, 6; 1918, **16**, 24) to the coffee industry of Uganda, and reports have been published on samples produced experimentally at the Government Plantations. Special attention is being given to *C. robusta* in these experiments, and this species is also being planted to an increasing extent by natives in the Buganda Province.

In continuation of the investigation of the coffee produced at the Government Plantations, a series of eleven samples representing coffee grown at Kampala was received in February 1918.

The samples were in good clean condition, and consisted of ungraded coffee berries in the parchment. Ten of the samples were stated to be derived from *C. robusta*, whilst the remaining sample was described as *Coffea* sp. cf. *eugenioides*. The berries were mostly oval in shape and flat on one side, but some "peaberries" were also present.

The samples were examined at the Imperial Institute with the results shown in the following table:

Sample.	Per cent. of parchment in berry.	Percentage of bean in berry.	Description of beans after the removal of parchment.			
			Average weight of a single bean.	Size of beans.	Colour of beans.	Description of seed coat.
			grams.			
(1) No. 11, Plot 1.	13	87	0·12	Small to medium	Opaque, greyish-cream	Light brown and on the whole close-fitting; in some cases easily removed
(2) No. 12, Plot 1.	10	90	0·17	Medium	Opaque, dull grey to creamy-grey	Greenish-grey and close-fitting
(3) No. 16, Plot 1.	12	88	0·16	Medium	Opaque, dull grey to creamy-grey	Greenish-grey to brown, and close-fitting
(4) No. 17, Plot 1.	14	86	0·09	Very small	Opaque, greyish-cream to grey	Light to medium brown, and close-fitting
(5) No. 25, Plot 1.	15	85	0·12	Medium to small	Opaque, greyish-cream	Light brown and mostly close-fitting; papery in some cases
(6) No. 1, Plot 3.	15	85	0·11	Small to medium	Opaque, greyish-cream to grey	Medium-brown and close-fitting
(7) No. 3, Plot 3.	16	84	0·13	Medium	Opaque, dull grey to creamy-grey	Light brown or silvery brown; fairly easy to remove
(8) No. 6, Plot 3.	16	84	0·12	Medium to small	Opaque, dull grey to creamy-grey	Greenish-grey to brown with some discolorations; close-fitting
(9) No. 9, Plot 3.	14	86	0·14	Medium	Opaque, greyish-cream to dull grey	Light brown and in most cases easily removed; close-fitting in a few cases
(10) No. 11, Plot 3.	18	82	0·14	Medium	Opaque, greyish-cream to dull grey	Light brown; loose and easily removed
(11) *Coffea* sp. cf. *eugenioides*	19	81	0·05	Very small	Translucent, light greyish-cream	Almost colourless; very thin, and close-fitting

The samples were submitted to a firm of brokers in London, who described and valued them as follows (June 1918):

Sample.	Description.	Value.
		Per cwt.
(1) No. 11, Plot 1.	Low quality, rather small beans, rough, and mixed with unripe beans . .	68*s.* to 73*s.*
(2) No. 12, Plot 1.	Fair sized, even, and well grown beans, very green and probably picked rather too soon; the appearance indicates good quality	78*s.* to 83*s.*

Sample.	Description.	Value.
		Per cwt.
(3) No. 16, Plot 1.	Generally similar to (2) (No. 12, Plot 1) above, and the discoloration noticeable on many of the beans indicates some sort of damage, probably caused during the process of curing	70*s*. to 75*s*.
(4) No. 17, Plot 1.	Beans similar to (1) (No. 11, Plot 1) above, but smaller	65*s*. to 70*s*.
(5) No. 25, Plot 1.	Fair quality, even beans, but rather rough and mixed with some unripe beans .	70*s*. to 75*s*.
(6) No. 1, Plot 3.	A common and undesirable quality of rather small and rough beans	60*s*. to 65*s*.
(7) No. 3, Plot 3.	Fair quality, of greenish colour, mixed with several defective beans . .	70*s*. to 75*s*.
(8) No. 6, Plot 3.	A common type, and very low quality, rough and undesirable	58*s*. to 63*s*.
(9) No. 9, Plot 3.	Fair-sized beans, common and very rough, but mixed with a few beans of good quality	63*s*. to 68*s*.
(10) No. 11, Plot 3.	Rather small beans, of fair and useful quality	75*s*. to 80*s*.
(11) *Coffea* sp. cf. *eugenioides*	Exceptionally small beans, smooth and well grown, and apart from the small size quite desirable and of good quality .	75*s*. to 85*s*.

The brokers stated that the samples were too small for roasting and liquor trials, so that the above report is based solely on the appearance of the raw coffee. They also expressed the opinion that when these coffees are husked in bulk by modern machinery, the results will be more satisfactory.

With reference to the prices quoted for the different samples it may be stated that the current market values are 10*s*. to 15*s*. per cwt. higher than those usually obtaining before the war for this class of coffee.

With the exception of Nos. 6 and 8 (No. 1, Plot 3, and No. 6, Plot 3, respectively) these samples of coffee are of satisfactory character, and would be quite suitable for the United Kingdom market.

In accordance with a suggestion made in a previous report (this BULLETIN, 1918, **16**, 27) a sample of Robusta coffee was forwarded from Uganda in June 1918, in order that roasting trials might be carried out.

The sample consisted of ungraded berries, in the parchment, of small to medium size. The parchment, which was of a light straw colour, showed slight discolorations, and was in some cases split open.

The seed coats, which adhered fairly firmly on the whole, varied in colour from brown to light brownish-green. The beans were of an opaque creamy-grey tint.

The berries consisted of beans 88·6 per cent., and parchment 11·4 per cent. The average weight of a single bean was 0·11 gram.

The sample was submitted for roasting trials to experts, who reported that it consisted of well-grown, heavy beans, rather small but very even in size ; only a few imperfect beans were present.

The characters of the roasted coffee were pronounced to be particularly good, especially in the evenness of colour and the close, hard texture of the beans, whilst the liquor was remarkably free from any undesirable taint. The firm regarded the sample as of excellent quality, and stated that it could be used freely for blending purposes.

The present sample represents a very desirable type of coffee, which would be quite suitable for consumption in the United Kingdom. Consignments of similar quality would always be readily saleable in London.

The experts who carried out the roasting trials had previously reported on all the samples of Robusta coffee recently forwarded to the Imperial Institute from Uganda, and they stated that the present sample was by far the best of the series. They suggested that it would be desirable to use this seed for propagation in Uganda.

3. Sudan

A sample of coffee was forwarded to the Imperial Institute by the Director of the Commercial Intelligence Branch, Central Economic Board, Khartoum, in January 1918. It was stated that the coffee had been grown at Kegulu Farm, and that it was desired to have information as to whether the cultivation of this type of coffee should be encouraged in the Sudan.

The sample consisted of coffee berries in the parchment. The berries were mostly of long oval shape and flat on one side, varying from moderately large to very large in size ; a few round "peaberries" were also present in the sample.

The parchment was of clear light buff tint, and was tough and somewhat difficult to remove. The beans were green to greenish-brown externally, and opaque and greenish-white within. The colour suggested that they had been gathered in an unripe condition.

The sample was examined at the Imperial Institute with the following results :

Percentage of parchment in the berries . . .	32
,, ,, beans ,, ,, ,, . . .	68
Average weight of a single bean	0·28 gram.
Number of beans required to fill a volume of 50 cc.	124

The proportion of parchment in the berries was high, the amount being usually only about 11 to 13 per cent.

A firm of brokers to whom the coffee was submitted stated that it was of the Liberian type, but that in comparison with other growths of this variety the beans were lacking in size and plumpness. They considered the sample to be of fairly good quality and worth about 78*s.* to 80*s.* per cwt. in bond in London after being husked (April 1918). They added that the sample had apparently been roughly prepared, and that the quality and appearance of the berries could be improved by more care and attention to the details of washing and fermenting the beans.

Another firm of brokers also stated that the coffee was of the Liberian variety, but much greener than is usual for this type. They regarded the sample as of good even " roast " and considered that consignments of similar character should meet with a ready sale in the United Kingdom market, principally however for export requirements. The firm valued the sample at about 75*s.* to 80*s.* per cwt. in London (April 1918), and estimated its value in normal times as about 60*s.* to 70*s.* per cwt.

There is no doubt that coffee represented by this sample would be readily marketable in the United Kingdom, especially if greater care were taken in its preparation. It is however of the Liberian type, which is usually regarded as inferior in quality to the Arabian variety, and before adopting Liberian coffee for extended cultivation at Kegulu it would be desirable to conduct experiments

with Arabian coffee for comparison. The Liberian coffee is of more robust habit than the Arabian, and as a rule grows better at low elevations, but the produce is not so valuable.

The Imperial Institute has suggested that the Department of Agriculture and Forests in the Sudan might conduct a series of trials with the two classes of coffee at suitable localities in the Sudan in order to determine which will be the most suitable variety for general cultivation.

SESBANIA—A FEEDING STUFF FROM SOUTH AFRICA

THE nutritive value and possible uses of the seeds of Sesbania from South Africa have been investigated at the Imperial Institute at the request of the Union Department of Agriculture.

The genus Sesbania (Nat. Ord. Leguminosæ) includes a number of shrubby annuals and perennials found in the tropics and sub-tropics of both hemispheres. Several species are grown as a green manure, and one, *S. aculeata*, also furnishes a useful fibre which is employed in India as a substitute for hemp in rope-making. In South Africa, according to the chief of the Division of Botany, the farmers regard Sesbania seed as an excellent poultry food.

No information was supplied as to the species of Sesbania yielding the seed examined at the Imperial Institute, but it was stated that the plant is an annual, attaining an average height of 3 to 4 ft. It appears to be indigenous to South Africa and is very plentiful in low-lying ground north of the Magaliesberg and on the Springbok Flats, Transvaal. It may be mentioned that the only species referred to in the *Flora Capensis* as occurring in South Africa is *S. aculeata*.

The sample consisted of small hard seeds having a shiny dark greenish-brown coat. The seeds measured about $\frac{1}{10}$ in. in length and possessed a fairly strong pea-like flavour and a slight aromatic odour.

The sample was submitted to chemical examination with the results shown in the following table, which includes for comparison the figures recorded for field beans, peas and soy beans :

	Sesbania seed. *Per cent.*	Field beans. *Per cent.*	Peas. *Per cent.*	Soy beans. *Per cent.*
Moisture	9·6	14·3	14·0	10·0
Crude proteins	32·9	25·4	22·5	33·2
Consisting of:				
True proteins	24·2	—	—	—
Other nitrogenous substances	8·7	—	—	—
Oil	6·2	1·5	1·6	17·5
Carbohydrates, by difference	39·0	48·5	53·7	30·2
Fibre	10·9	7·1	5·4	4·4
Ash	1·4	3·2	2·8	4·7
Nutrient ratio[1]	1 : 1·6	1 : 2·0	1 : 2·6	1 : 2·1
Food units[2]	137	116	114	157

[1] *The ratio between the percentage of crude proteins and the sum of the percentages of starch and fat, the latter being first converted into its starch equivalent.*

[2] *The total obtained by adding the percentage of starch to 2·5 times the sum of the percentages of fat and crude proteins.*

The seeds yielded no prussic acid.

The results of the analysis show that these Sesbania seeds contain a high percentage of protein and about 6 per cent. of oil. They compare favourably in composition with other leguminous seeds such as field beans, peas and lentils, but contain less oil than soy beans.

Samples of the seeds were submitted to grain and seed merchants, and to manufacturers of feeding stuffs, for opinions as to their probable uses and value. The merchants reported that there has been no actual experience of Sesbania seeds in this country, and that it is difficult to supply any definite information regarding them without having trials made. Judging from the character of the seeds and the results of the analysis, they considered that the Sesbania seeds might be utilised in place of peas, lentils and millet, and that if so their value might approximate to that of the latter products, the spot price of which in London is abnormally high at present, viz. £40 per ton (January 1919). Feeding trials would however be necessary to determine their precise value. It is suggested that a trial consignment of 5 tons of the seed should be sent to London.

The manufacturers reported that in their opinion the Sesbania seeds could be utilised in the manufacture of feeding stuffs, and they estimated their value for this purpose at £17 per ton ex quay Liverpool (January 1919).

There do not appear to be any published records of the use of Sesbania seed as a feeding stuff for cattle. It is stated however that "Sesbania pea" is grown in South California and Mexico for its stalk fibre, which is used for rope making, and that the seed is obtained as a by-product and converted into meal. A sample of the seed is said to have been valued in England in 1910 at £5 per ton c.i.f. London with soy beans at £8 per ton at Hull.

The small size and hard coat of the seed are to some extent disadvantages, but apart from this the seeds have a high food value, and would no doubt find a market in the United Kingdom if trials should prove them to be quite harmless to animals. Information has been requested as to whether a trial consignment of at least 5 tons can be forwarded to the Imperial Institute.

THE FRUIT OF THE SOUTH AMERICAN NOLI PALM AS A SOURCE OF OIL

Of the many oil-yielding palms of tropical South America, one of the most important is *Elæis melanococca*, Gaertn. This species is very similar in character to *E. guineensis*, the West African oil palm, but is smaller in size. It appears to be common in Colombia, where it is known as "Noli" palm, and a supply of the entire fruits was received recently from that country, where they are stated to be available in large quantities.

The fruits were dry, of orange-yellow or greyish colour, and measured from 0·8 to 1·0 in. in length and from 0·5 to 0·8 in. in diameter. They were smaller than the average size of *E. guineensis* fruits and were rather pointed at the ends. The average weight of a single fruit was 2·5 grams. The pericarps of the greyish fruits had appar-

ently undergone deterioration and contained practically no oil.

The shells of the nuts were very hard, and about $\frac{1}{10}$ in. in thickness. About 8 per cent. of the nuts contained two kernels, and the remainder one.

The kernels were similar to West African palm kernels derived from *E. guineensis*, but were smaller. The average weight of a single kernel was 0·5 gram.

Fruits.—The fruits were found to consist of pericarp 16 per cent., shell 62 per cent., and kernel 22 per cent. The nuts therefore formed 84 per cent. of the entire fruits.

The proportion of pericarp in these Noli fruits is much lower than in any of the ordinary West African oil-palm fruits derived from *E. guineensis*, and fruits of the quality represented by the present sample would consequently only give a low yield of pericarp oil (see below).

Pericarp.—The pericarp of the sound fruits contained 8·1 per cent. of moisture and 29·0 per cent. of oil, equivalent to 31·5 per cent. of oil from the dry pericarp. The yield of oil from the entire fruits was therefore only 4·6 per cent.

The oil was an orange-yellow liquid containing a fairly high proportion of separated stearine. It was much more liquid and paler in colour than commercial palm oil from West Africa, but possessed a similar taste and smell.

The following table shows the results of the chemical examination of the oil in comparison with the corresponding figures for commercial palm oil from *E. guineensis* :

	Pericarp oil from Noli palm fruits.	Commercial West African palm oil (*E. guineensis*).
Specific gravity at 100/15° C.	0·8636	0·8586
Solidifying point of fatty acids	33·6° C.	36° to 46° C. (usually 44° to 45° C.)
Acid value [1]	29·7	—
Saponification value [1]	199·0	196 to 205
Iodine value *per cent.*	83·5	53 to 57
Unsaponifiable matter, *per cent.*	0·7	—
Volatile acids, soluble	0·7	0·86 to 1·87
,, ,, insoluble	0·5	—

[1] *Milligrams of potash for 1 gram of oil.*

The pericarp oil of *E. melanococca* has a higher iodine value than commercial palm oil, and differs from the latter in general characters.

Kernels.—The kernels were found to contain 7·2 per

cent. of moisture and 45·4 per cent. of oil, equivalent to 48·7 per cent. from the dry kernels.

The oil was a solid fat of pale cream colour with a pleasant taste and smell. It was of similar character to palm kernel oil, and slightly harder than ordinary coconut oil.

The oil was examined with the results shown in the following table, which includes for comparison the figures for West African palm kernel oil :

	Kernel oil from Noli palm fruits.	Commercial West African palm kernel oil (*E. guineensis*).
Specific gravity at 100/15° C.	0·8651	0·8731
Solidifying point of fatty acids	26·9° C.	20 to 25·5° C.
Acid value [1]	0·6	—
Saponification value [1]	234·0	243 to 255
Iodine value *per cent.*	27·7	10·3 to 17·5
Unsaponifiable matter, *per cent.*	0·8	—
Volatile acids, soluble	1·4	5·0 to 6·8
,, ,, insoluble	3·0	10·0 to 12·0

[1] *Milligrams of potash for 1 gram of oil.*

The pericarp of these Noli palm fruits was extremely thin, even in the case of the fruits which were apparently in good condition, and the yield of pericarp oil was consequently very low in comparison with that obtained from the ordinary thick-shelled varieties of West African palm fruits. As already stated the yield of pericarp oil from the present sample was only 4·6 per cent. expressed on the entire fruits, as compared with 17 to 23 per cent. from ordinary thick-shelled varieties of West African palm fruits. If therefore the present sample is thoroughly representative of the Noli palm fruits from Colombia it seems doubtful whether the pericarp will be of much value as a commercial source of oil.

The kernels of the nuts contain rather less oil than West African palm kernels, and the oil is of a slightly different character, but there is no doubt that Noli palm kernels would be readily saleable in the United Kingdom. In February 1919 West African palm kernels were selling in the United Kingdom at the controlled price of £26 per ton on a basis of 49 per cent. of oil ; before the war the price fluctuated considerably, being sometimes only £14 per ton, and at other times as much as £23 per ton.

Noli palm fruits, as represented by the present sample, would only be of commercial interest on account of the kernels which they contain. These kernels, if separated from the fruits in Colombia, would find a market in the United Kingdom in competition with palm kernels from West Africa. Information has been requested by the Imperial Institute as to whether shipments of the kernels could be made, and the price at which they could be offered.

The low yield of pericarp oil from these Noli palm fruits deserves further investigation, and it would be of interest to ascertain whether Noli fruits of larger size or better quality are obtainable in Colombia. The Imperial Institute has suggested that if such fruits are available in quantity, representative samples, taken from bunches gathered from a number of trees, might be forwarded for further examination.

FURTHER INVESTIGATIONS ON THE VALUE OF CINNAMON BARK FROM THE GOLD COAST

In a previous number of this Bulletin (1918, **16**, 146) an account was given of the results of examination of a sample of cinnamon bark grown at the Tarquah Agricultural Station in the Gold Coast. It was shown that the bark gave a high yield of oil of good quality, and three samples produced respectively at the Assuantsi, Coomassie and Aburi Stations have since been received for examination in comparison with the earlier sample.

The three samples were as follows:

No. 1. *From Assuantsi.*—This consisted of pieces of rolled bark, of pale reddish-brown colour, about 10 in. in length and 1 in. in width. The rolls were very irregular in shape, and much scarred and torn.

The aroma of this material was inferior to that of Ceylon cinnamon bark.

No. 2. *From Coomassie.*—This sample consisted of rolls of bark measuring 12 in. in length and 1 to 1½ in. in width. The material resembled sample No. 1, but possessed a better aroma.

No. 3. *From Aburi.*—This bark was in rolls about 9½ in. long and ¾ in. wide. It was similar in appearance to sample No. 1, though somewhat paler, whilst the aroma was more fragrant than that of sample No. 1, but not equal to that of sample No. 2.

Distillation trials were carried out with the three barks at the Imperial Institute in order to determine the yields of volatile oil which they furnished, and the results are shown below in comparison with the corresponding figures for the previous sample from Tarquah referred to above :

	Sample No. 1 from Assuantsi. *Per cent.*	Sample No. 2 from Coomassie. *Per cent.*	Sample No. 3 from Aburi. *Per cent.*	Previous sample from Tarquah. *Per cent.*
"Heavy" oil which separated from the aqueous distillate	1·5	1·6	1·4	1·18
"Light" oil extracted with ether from the aqueous distillate	0·3	0·4	0·3	0·30
Total yield of oil . .	1·8	2·0	1·7	1·48

It will be seen that the yields of oil from the present samples are somewhat higher than that furnished by the previous sample from Tarquah. They are also considerably in excess of those yielded by Ceylon cinnamon bark, which vary from 0·5 to 1·0 per cent.

All four samples of "heavy" oil had a very fragrant aroma, and closely resembled one another in this respect.

The "heavy" oils from the present samples were submitted to chemical examination with the results shown in the following table, which includes the figures for the sample from Tarquah and also the requirements of the British Pharmacopœia for Ceylon cinnamon oil :

	Sample No. 1 from Assuantsi.	Sample No. 2 from Coomassie.	Sample No. 3 from Aburi.	Previous sample from Tarquah.	Requirements of the British Pharmacopœia for Ceylon cinnamon bark oil.
Specific gravity at 15/15° C.	1·038	1·042	1·041	1·042	1·000 to 1·030
Refractive index, n/D .	1·594	1·606	1·603	1·603	1·565 to 1·580
Aldehydes, *per cent.*	74 (approx.)	88 (approx.)	86 (approx.)	86 (approx.)	55 to 65
Solubility in 70 per cent. alcohol	Soluble in 2·5 vols.	Soluble in 2·4 vols.	Soluble in 2·4 vols.	Soluble in 2·4 vols.	Soluble in 3 to 4 vols.

It will be noticed that sample No. 2, which gave the largest yield of oil, also contained the highest percentage

of aldehydes. When distilled on a large scale the three present samples should yield "entire" oils (*i.e.* the "heavy" and "light" fractions together) containing at least 61, 70 and 70 per cent. of aldehydes respectively.

The results of this investigation show that these cinnamon barks from the Gold Coast are of very good quality, as they furnish a high yield of oil which contains a large percentage of cinnamic aldehyde. In both these respects the barks are superior to Ceylon cinnamon bark.

As stated in the previous report (*loc. cit.*, p. 147) it would be desirable to carry out distillation trials on a larger scale in order to determine the yield and quality of the oil obtainable under commercial conditions. For this purpose a consignment of a few cwts. of the bark would be required, and information has been requested as to whether this quantity can be supplied. It was suggested that if this amount of bark is not available at any one of the Stations, a composite sample might be made up from all the Stations, as the four samples of bark only differ slightly in quality.

THE RED SEA AS A SOURCE OF MOTHER-OF-PEARL

The ordinary mother-of-pearl shell, together with other less valuable kinds, occurs along the African coast of the Red Sea, and the collection and export of the shells forms a minor industry in the Sudan. The shells are obtained in comparatively shallow water by the natives, who dive as a rule without apparatus of any kind. According to the official trade returns, the quantity exported varies considerably from year to year, the amounts and values of the exports in recent years being as follows:

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Cwts.	*£E.*[1]		*Cwts.*	*£E.*[1]
1912	810	2,475	1916	2,920	11,012
1913	3,654	15,369	1917	1,013	4,053
1914	631	2,304	1918	286	733
1915	938	3,580			

[1] *£E = £1 0s. 6½d. sterling.*

Up to 1914 most of the shells were shipped to the United Kingdom, but during the war they were sent almost

entirely to Eritrea, India and Aden, and Egypt. The chief port of shipment in the Sudan is Suakin.

Samples of mother-of-pearl shells from the Sudan were sent to the Imperial Institute in 1911 in order to ascertain their commercial value. They were as follows:

A. Ten shells, varying in size from 6 by 6 in. to 6 by 7 in. and in weight from 7 oz. to 15 oz. Two shells showed "worm holes" on the outer surface.

B. Ten shells, varying in size from 5½ by 6 in. to 6 by 6½ in., and in weight from 6½ to 7¾ oz. All were cracked at the margins and one was broken. Three shells showed "worm holes" on the outer surface.

C. Ten shells, varying in size from 5½ by 5½ in. to 5½ by 6½ in., and in weight from 5½ to 6 oz. All were slightly cracked at the margin, and two showed "worm holes" on the outer surface.

D. Ten shells, varying in size from 4 by 4½ in. to 4½ by 5½ in. and of an average weight of 2½ oz. Slight cracks were present at the margins of one or two of the shells, but no "worm holes" were observed.

E. Ten shells, averaging 3½ by 3¾ in. in size and 1 oz. in weight. They were free from cracks and "worm holes."

F. Seven whole shells, averaging 4 by 4½ in. in size and 3½ oz. in weight.

In samples A to E the shells were all of good colour and appearance, but in sample F they were somewhat opaque and stained on the inner surface.

The shells were submitted to two firms of brokers for valuation in May 1911, with the following results:

Sample.	I.		II.	
	Remarks.	Valuation.	Remarks.	Valuation.
		Per cwt.		*Per cwt.*
A	Medium to bold, not very stout, fair colour and clean	£6 to £6 10*s*.	Medium and bold, A size, sound and clean	£7
B	Stout medium, fair colour and clean	£5 10*s*.	Fair B size, a few slightly wormy	£5 10*s*.
C	Thin medium, fair colour and clean	£4 5*s*. to £4 10*s*.	Smaller in size and thinner substance	£5
D	Chicken, fair colour	£2 15*s*. to £3	D size and bold oysters	£4 5*s*. to £4 10*s*.
E	Oysters, fair colour	£2 5*s*. to £2 7*s*. 6*d*.	Oysters size, clean	£2 7*s*. 6*d*. to £2 10*s*.
F	Stale and dead	£1	Stale and dead	10*s*.

The first firm stated that there is a fair demand in London for this class of shell, and that imports might be encouraged. They reported that the colour of the samples was good, but that the shells should be of a little stouter substance, especially those represented by sample A, which would then realise 5*s.* to 10*s.* per cwt. more than the valuation quoted above. The firm added that samples A, B and C represented the best grades of shell for the London market.

The second firm stated that their valuations were for sound and clean shells, adding that when consignments arrive in London they usually contain some "grubby" and "wormy" shells, which are sorted out and sold separately.

As most of the shells in these samples would find a ready sale in London it was suggested that a trial consignment might be forwarded to the Imperial Institute for disposal at the public sales. Three consignments were subsequently received, and were sold in London through brokers at the following prices:

Number of cases.	Description.	Price realised. Per cwt. £ s. d.	Date of sale.
	First consignment		
1	Stout medium, fair colour	8 0 0	May 1912
3	Thin medium, fair colour	7 12 6	,,
4	Chicken, fair colour	7 2 6	,,
8	Oyster	5 2 6	,,
1	Broken pieces	4 15 0	,,
5	Grubby pickings	5 5 0	,,
28	Stale	4 10 0	,,
	Second Consignment		
1	Chicken	6 17 6	May 1912
2	Oysters	5 12 6	,,
1	Broken and defective	3 0 0	,,
31	Stale	4 15 0	,,
	Third Consignment		
1	Thin medium, fair colour	8 0 0	Jan. 1913
2	Chicken and oyster	6 0 0	,,
3	Chicken and oyster, slightly defective	2 0 0	,,
54	Slight stalish	3 2 6	,,

The prices realised are quite satisfactory for this class of shell, but are much less than those of the finer sorts from Australia and Manila.

In May 1918 a further series of five samples was forwarded to the Imperial Institute in order to determine their quality and commercial value. The shells were stated to have been obtained from three distinct localities, and were described as follows:

Sample.	Description.
No. 1	Sound shells.
No. 2	Defective shells.
No. 3	Sound shells.
No. 4	Defective shells.
No. 5	Sound and defective shells together, but believed to be of better quality than Samples 1 to 4.

The samples were submitted for valuation to a firm in London who stated that the samples compared very favourably with average Red Sea mother-of-pearl shells, except that Nos. 2, 4 and 5 were rather yellow. They described and valued the samples as follows:

Sample.	Description.	Approximate value in London (April 1919). Per cwt.
No. 1	Sound shells, medium substance, fair colour	85*s.*
No. 2	Slightly defective, medium substance, rather yellow	45*s.*
No. 3	Sound shells, similar to No. 1	85*s.*
No. 4	Slightly defective, rather yellow, rather inferior to No. 2	35*s.* to 40*s.*
No. 5	Apparently sound shells, stout and medium but very yellow	80*s.*

Another firm who examined the samples reported that they represented a fair average of the lower quality of Red Sea shells. They considered the present and pre-war values of the shells to be as follows:

Sample.	Value in London (April 1919). Per cwt. £ s. d.	Approximate pre-war value. Per cwt. £ s. d.
No. 1	5 0 0	3 15 0
No. 2	2 10 0	2 0 0
No. 3	5 10 0	4 0 0
No. 4	2 10 0	2 0 0

With reference to sample No. 5 this firm stated that the shells were superior to those of Samples 1 to 4; and that the sound and defective shells would probably be worth 5*s.* to 10*s.* per cwt. more than Samples 1 and 2, *i.e.* the sound shells £5 5*s.* to £5 10*s.* and the defective shells

£2 15s. to £3 per cwt. The pre-war value of this sample would have been about £3 per cwt.

The pre-war values which the second firm assigned to the samples were those ruling on the average in 1914, and not the inflated prices which were current for a short period.

Mother-of-pearl shells represented by this set of samples would be readily saleable, and both the firms consulted stated that consignments might be forwarded to London for disposal. It is anticipated that there will be a considerable revival of the button-making industry as soon as conditions become more normal, and it is hoped that the monthly shell auctions in London will be resumed shortly.

SPECIAL ARTICLE

THE EXTENSION OF COTTON CULTIVATION IN EGYPT

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An historical account of the cultivation and development of cotton growing in Egypt is furnished by the writer in *Egyptian Agricultural Products*, No. 3A—"Cotton," published by the Ministry of Agriculture, Cairo. From this it will be seen how the cultivation has followed the extension of the summer irrigation canals, increasing annually with small fluctuations until the total area under cotton in 1913–14, given by the Department of Direct Taxes, reached 1,775,270 feddans or Egyptian acres (equal to 1,822,058 English acres). The total area of cultivated land in Egypt, and the percentage under cotton, are shown in the table on p. 196.

Examining the details of these figures, we find that in Lower Egypt, although the total area of cultivated land has remained fairly constant during the ten years ending 1913–14, the proportionate area under cotton has increased by nearly 6 per cent., reaching 45·4 per cent. of the total cultivated area of that region. Later years cannot be taken into consideration owing to the artificial factors introduced by the war.

Year.	Lower Egypt.		Upper Egypt.		Total.	
	Total area of cultivated land.	Percentage under cotton.	Total area of cultivated land.	Percentage under cotton.	Total area of cultivated land.	Percentage under cotton.
	Feddans.		*Feddans.*		*Feddans.*	
1904–5 .	3,157,321	39·7	2,246,570	13·8	5,403,891	28·9
1905–6 .	3,132,538	40·2	2,207,100	11·1	5,339,638	28·0
1906–7 .	3,167,077	40·4	2,235,639	14·0	5,402,716	29·6
1907–8 .	3,174,627	40·9	2,151,885	15·8	5,326,512	30·8
1908–9 .	3,122,411	42·5	2,251,571	12·0	5,373,982	29·7
1909–10 .	3,100,233	42·7	2,245,119	14·1	5,345,352	30·7
1910–11 .	3,022,304	44·5	2,241,554	16·6	5,263,858	32·5
1911–12 .	3,038,932	44·3	2,246,522	16·7	5,285,454	32·5
1912–13 .	3,052,916	43·9	2,229,710	17·2	5,282,626	32·6
1913–14 .	3,019,510	45·4	2,003,720	19·0	5,023,230	34·9
1914–15 .	3,045,014	30·8	2,263,876	11·0	5,308,890	22·1
1915–16 .	3,012,983	42·8	2,219,288	16·4	5,232,271	31·6

It is apparent from this that cotton comes into the crop rotation, in a large part of the country, twice in three years, and that the old triennial rotation has, to a large extent, disappeared.

In Upper Egypt, the fluctuation of the area under cotton is always to some extent affected by the behaviour of the Nile flood, as a certain proportion of each year's crop is grown in the basin lands, which have not yet been placed under perennial irrigation by canals. But, even with this factor influencing the result, we find a steady increase in the cotton area from 1908–9 to 1913–4, amounting to 5·2 per cent. in the six years reviewed.

From the best agricultural standpoint, the limit of cotton area has been reached in the cultivated lands of Lower Egypt, but there still remain cultivable lands for reclamation, as well as insufficiently drained but cultivated tracts, which may be so improved as to be rendered capable of greatly increasing their productivity. These categories will each be dealt with in turn. In Upper Egypt, the problem for the increase of cotton production rests mainly on the conversion of the large basin areas into perennially irrigated ones, but to some extent also, upon the supply of certain areas outside the existing basins with a perennial water supply.

In order to obtain as accurate an idea as possible with regard to the cultivated and the cultivable but uncultivated

lands in the country, a map was prepared showing, according to contour lines, where the Nile water could reasonably be brought and applied by canals without involving any abnormal degree of lift in watering the adjoining land. To this end, all the higher lands were excluded and deductions were made in the cultivable lands for those parts applied to public utility, such as town and village sites, roads, railways, canals, monuments, ancient city sites and the bed of the Nile at summer level. In addition to this the following areas were excluded: the whole of the Mediterranean littoral province of Mariout, the oases of Kharga, Dakhla, Siwa, Bahria, etc., and all the lands east of the Suez Canal or otherwise unapproachable by the Nile water canals. The areas measured by the Egyptian Survey Department were given as follows:

	Egyptian acres or feddans.[1]
Perennially irrigated land	4,513,000
Basin areas	1,108,598
Cultivable but not yet cultivated land	1,258,000
Total	6,879,598

[1] *The feddan or Egyptian acre is equal to* 1·03805 *English acres.*

In addition the areas of the great lakes in the North, which form a project for future extension, are given as follows:

	Egyptian acres.
Mariout	59,000
Edku	50,000
Menzaleh	407,000
Borollos	140,000
Total	656,000

The figures given are those obtained by measurement on the map, and are sufficiently accurate for the purpose; they are not, however, guaranteed by the Survey Department, nor do they quite correspond with the totals given in the Cadastral Survey, which are taken into account in dealing separately with the provinces. The difference, however, is only 1 in 170, and can be ignored for the present purpose. The figures for cultivable land, after deducting

public utility lands, according to the Cadastral Survey, are as follows :

	Egyptian acres.
Lower Egypt	4,192,547
Upper Egypt	2,641,297
Total	6,833,844

This estimation is therefore 45,754 Egyptian acres lower than the result obtained from measurements on the map.

Excluding the lake area for the present, there are, in round figures, 5,600,000 Egyptian acres already cultivated, watered either by summer canal supply or by flood, and there remain 1,250,000 Egyptian acres as yet unfurnished with water, but capable of becoming productive of crops at some future time, when the necessary canalisation and river-works have been developed, to enable the Nile water to reach them.

It is safe to conclude that, when the necessary irrigation projects have been completed, every portion of the cultivated land of Lower Egypt will be capable of growing cotton once or twice in a three-years rotation ; but the same cannot be said to be precisely the case with respect to Upper Egypt.

In the southernmost provinces of the latter locality, climatic conditions are found which preclude the successful cultivation of cotton on a large scale. These conditions may be said to apply only to the provinces of Aswan, Qena and Girga, where, although perennial irrigation is supplied to a tract of 40,000 feddans alone (Kom Ombo Estate) in Aswan, no cotton is grown upon it, and that crop represents annually only just over 1 per cent. in Aswan, and under 1 per cent. of the total cultivated area in each of the other provinces named. Assuming that perennial water supply were granted to these provinces, it is fair to assume that not more than 10 per cent. in Aswan, 15 per cent. in Qena, and 20 per cent. in Girga would annually bear cotton. Calculating this on the triennial rotation basis, 30, 45 and 60 per cent. of the cultivable land in each of these provinces, respectively, would bear cotton once within a period of three years.

The ultimate cotton-bearing areas in these three provinces may therefore be put down as follows, after making a deduction of 5 per cent. for roads and canals in converting the basins and unwatered tracts :

	Cultivated once in 3 years with cotton. *Egyptian acres.*	Annually under cotton. *Egyptian acres.*
Aswan	40,000	13,300
Qena	164,000	54,600
Girga	193,000	64,300
Total	397,000	132,200

In the remainder of Upper Egypt, comprising about 1,850,000 Egyptian acres, of which 743,000 Egyptian acres of basin and unwatered land would have to be canalised, there would be a loss in area by conversion, calculated at 5 per cent. on the last figure, or 37,000 Egyptian acres, making the corresponding figures to those given above as follows :

	Bearing cotton once in 3 years. *Egyptian acres.*	Bearing cotton annually, say, 40 per cent. *Egyptian acres.*
Rest of Upper Egypt	1,813,000	725,000

The figures for both Upper and Lower Egypt are therefore as follows :

	Total land. *Egyptian acres.*	Cultivable in cotton. *Egyptian acres.*	Annually in cotton. *Egyptian acres.*
Upper Egypt	2,688,000	2,210,000	857,000
Lower Egypt	4,192,000	4,142,000	(45%)1,864,000
Totals	6,880,000	6,352,000	2,721,000

Taking the normal cotton area of Egypt at 1,716,000 Egyptian acres, it would therefore be possible to cultivate annually, upon the same system of rotation as that at present in vogue, an additional 1,005,000 Egyptian acres. This, it must be observed, involves bringing into the scheme of perennial irrigation a new area of 2,366,000 Egyptian acres, made by converting the whole of the basin and previously unwatered areas, from which will result a net cultivated area, after making deductions for roads and canals, of 2,249,000 Egyptian acres.

To ascertain the actual maximum area, the lake areas

must be taken into account. These consist of very large shallow tracts slightly below sea-level, which doubtless could be drained and rendered capable of growing cotton, much in the same manner as has already been done to a portion of the lake in the vicinity of Abu Qir. The area of these lakes is, as has been mentioned before, 656,000 Egyptian acres, which, in the course of conversion, would be reduced by 5 per cent. for canals, drains, and roads to 624,000 Egyptian acres. This land, when properly drained, would probably be suitable in the first place for a rotation of cotton and rice, with intermediate clover. On this rotation, 50 per cent. would be under cotton annually, and would give an additional 312,000 Egyptian acres to the previous total, making a total of 3,033,000 Egyptian acres annually capable of yielding cotton.

With regard to productiveness, supposing the present degree of depreciation in quantity by the ravages of the pink boll worm be maintained, it may be assumed that the normal crop of the existing cultivated area is four qantars per Egyptian acre (1 qantar = 99·049 lb.), of which Lower Egypt averages 3·9 qantars per Egyptian acre, and Upper Egypt 4·4 qantars of the inferior (Ashmouni) cotton. Special circumstances, dependent chiefly on the European War, have recently influenced the cotton yields, rendering them somewhat below the average given here. It is, however, probable that when normal conditions again prevail the crop average will not fall below the estimate given.

Assuming then that the new areas to be brought under cultivation are as stated here, the total annual production may be calculated as follows:

	Area. *Egyptian acres.*	Yield. *Qantars per Egyptian acre.*	Total yield. *qantars.*
Lower Egypt	1,864,000	3·9	7,270,000
Upper Egypt	857,000	4·4	3,190,000
Lake Areas	312,000	2·5	780,000
Total	3,033,000	—	11,240,000

It will be noted that, although some of the best land, and that certainly capable of growing the finest quality of cotton, is found in Lower Egypt, the average yield per

Egyptian acre is comparatively low. This is accounted for by the fact that a very large area in the northern part of the Delta has become impoverished in late years, owing to the rising water-table and the lack of adequate drainage. In these lands, it becomes nearly imperative that, in each alternate year, a rice crop shall be planted, in order to wash and sweeten the land sufficiently to make it yield even a meagre crop of cotton, as the salt returns annually with the rise of the subsoil water at flood time. The probable area of land bearing cotton under these unfavourable conditions in any one year is between 400,000 and 500,000 Egyptian acres, and the yield per Egyptian acre from this does not average more than 2·5 qantars. If properly drained, with lift drainage, it should easily be made equal to the rest of the Delta with respect to productiveness, and, at a moderate estimate, should produce an additional 1·5 qantars per Egyptian acre, or, say, 650,000 qantars more.

The amelioration of this land is at the same time the most economical as well as the most necessary work to be taken in hand, and should repay the labour expended upon it much sooner than the reclamation of new lands, etc. It is of primary importance, because almost any other locality, in which the Nile water is to be employed in the reclamation of new lands, is nearer to the sea, and requires its irrigation canals to pass through these already cultivated but poorly drained lands, thereby further injuring them by the infiltration which must follow. The economy of dealing with these lands in the first instance is exemplified also by the fact that less water would be required foı them after adequate drainage was given, by reason of rice cultivation becoming no longer a necessity and being replaced by wheat and maize ; these two crops together requiring from one-third to one-half the water taken by one rice crop, and drawing almost entirely on the flood supply of the river, instead of stored water. In every other project, more summer water would be required to be provided by the Nile, and in consequence the construction of barrages and storage dams would be involved. Gravitation-drains, with lifts at suitable intervals to compensate for the depressions in which these lands are mostly found,

seem to be practically the only requirements to render them sufficiently fertile. During recent years, it is true that a great deal has been done to rectify the errors of the original system of canalisation, which was unaccompanied by adequate drainage, but the point made here is that the first step towards increasing cotton production in Egypt should be the amelioration of these lands.

The second question in order of importance, I believe, is that of supplying summer water to the basins in Upper Egypt. This tract, which, from the point of view of quality of cotton, can only supply a lower grade than Lower Egypt, could, if furnished with summer water, assist to such a degree in the supply of food for the population of Egypt, in addition to furnishing Ashmouni cotton, that the importance of it in this respect gives it prominence. The canalisation of the basins would necessitate additional water storage, or, at any rate, the construction of another barrage, or barrages, upon the Nile.

Before dealing with the next question in order of importance for Egypt, it is necessary to refer to the fact that the Sudan, as well as Egypt, is dependent upon the Nile for its water-supply, and that, in any consideration of additional water provision from the river, the claims of the Sudan must be recognised. With regard to cotton production alone, it is probable that the development of the Gezira scheme is of as much importance as the canalisation of new areas in Egypt. The renovation of the existing lands and the canalisation of the basins would necessarily occupy many years, during which time the Sudan could not be expected to stand still. Apart from its cotton-growing claims, the Sudan requires the development of large areas, not entirely dependent on rainfall, to provide for her increasing population, and doubtless for many political reasons besides. On this account it is important that no less energy should be devoted to the irrigation schemes of the Sudan than to those of Egypt.

The canalisation of new areas in Egypt is so largely dependent upon the proper carrying out of the two previously mentioned schemes that little can at present be said with reference to it, except that in all works carried out in connection with the latter the claims of the former must

be borne in mind. It may involve the introduction of a slight lift of water from canals to replace free flow, which is thought by many competent people in Egypt to be an advantage, inasmuch as it gives less opportunity for the cultivators to indulge in overwatering, and the drainage question then becomes a less onerous one.

The last means of increasing the cultivable area, namely, by the reclamation of the Northern Lakes, presents many difficulties in addition to those connected with engineering work. These lakes at present constitute the chief fishing-grounds in Egypt, and enormous quantities of fish are captured there for distribution all over the country. This industry appears capable of extension, and should become a very important one. In addition to the perpetual fishing-rights, which are held by a certain proportion of the population, the collection of reeds for mat and basket-making gives employment to another class of workers.

Although this account deals expressly with the possible extension of cotton areas, it would scarcely be complete without reference being made to the temporary reductions of the same which have been occasioned during recent years owing to the war. By many unacquainted with local circumstances, the reduction of the cotton area in 1915 has doubtless been quite misunderstood. The recommendation for the reduction referred to emanated from a Committee formed in England to consider the matter. It was, however, carried into effect voluntarily by the cultivators themselves, who had experienced great difficulty in harvesting their cotton in the previous year, owing to the impossibility of obtaining the usual financial assistance at picking-time, and who even found themselves unable to obtain a price for their cotton when picked. Whether the reduction of the cotton area was entirely the result of a voluntary and independent decision of the cultivators themselves without their being influenced by the Law, is a matter of uncertainty, but the fact that the Law itself only limited the planting of cotton to the extent of one-third of each holding, and the result showed that even less than this proportion was eventually planted in every province, points to the Law not being wholly responsible for the diminution.

The wisdom of the restriction, whether voluntary or compulsory, was proved by the fact that Egypt was able, for the first time for many years, to feed herself, as well as to export food-grains to England at a critical time, and was also enabled to plant a nearly full crop of cotton in 1916, which obtained the highest prices ever reached.

The later restriction of the cotton area was carried out under rather different conditions, as the ruling price for cotton was still sufficiently high to encourage the cultivator to plant heavily, while there was no compensating inducement to increase the production of cereals, except the necessity occasioned by restricted importation of food. The situation was one fraught with many difficulties, and the influences restricting the cotton area in 1918 were again those emanating from circumstances outside the country.

Something may be said with respect to the kinds of cotton which it is probable may be grown in Egypt in the near future. Although the matter is one of very great uncertainty, still, judging by the recent changes which have occurred in the characters found desirable both from the spinner's and cultivator's points of view, it is assumed that Sakellaridis cotton will occupy the attention of growers throughout the Delta for some years, and that there is very little likelihood of a return to the old Brown types of cotton—Nubari, Assili, and Afifi. Upper Egypt will continue to cultivate Ashmouni, which has been somewhat improved. The most important change in the cultural requirements of Egyptian cotton is that, whereas up to less than ten years ago, it was not uncommon to continue picking until December, most of the crop is now finished, even in Lower Egypt, by the end of September; and the yield per Egyptian acre in these cases is often quite as good as previously. This early maturing character has become of the first importance by reason of the ravages of the pink boll worm, and is, in addition, of great assistance in the sowing of the crops which follow.

In conclusion, it must again be emphasised that the extreme area capable of being cultivated in cotton can only be attained as the result of a great deal of careful irrigation engineering, and after the expenditure of much time and money.

GENERAL ARTICLES

THE FUTURE OF WHEAT PRODUCTION WITH SPECIAL REFERENCE TO THE EMPIRE

In view of the importance of the question of the future of wheat production, the present article has been prepared by Mr. A. S. Judge, lately Chief Collector of Customs, Burma, from published information and material available at the Imperial Institute.

Wheat in Relation to Other Cereals

In dealing with the question of the consumption and disposal of the wheat crops of the world, it is essential that those of other cereals should be taken into consideration, for in times of shortage these grains are substituted for wheat, and some of them provide the staple food of the inhabitants of various parts of the world.

World's Production of Cereals

Wheat and rice are the two principal cereals which provide food for mankind; millets, rye, maize, barley, and oats, especially the first three, are used as human food in many countries, but are more generally used in Western countries for feeding live-stock. The annual production of wheat in the world amounts to about 110,000,000 tons, while that of rice, assuming that the outturn in China is equal to that of India, is about 90,000,000 tons. Rice is the staple food of the majority of the inhabitants of India, China, Siam, Japan, Korea, Formosa, the Philippine Islands, Ceylon, and the Malay Peninsula and Archipelago; it may be estimated that more than one-third of the human race are rice-eaters. Wheat is the principal bread grain of the Western nations, and the world's production of this grain is almost entirely converted into flour, in the course of which process various by-products are obtained which are used as cattle food. Wheat

provides food for the majority of the inhabitants of Europe, America, Australasia, Northern Africa, and of those parts of Asia where rice is not the staple food.

In Northern and Central Europe, black bread made from rye takes the place of wheaten bread among the poorer classes. The estimated production of rye in the world is about 45,000,000 tons, of which more than one-half is raised in Russia, and one-fourth in Germany. Rye is also grown in the United States, and during the war Scandinavian countries obtained their requirements of rye and rye flour largely from this source.

There is an increasing demand for wheaten flour throughout the world; it has been replacing rye in Europe, and in Germany the average consumption of wheat per capita advanced from 130 lb. for the ten years ending 1889 to 190 lb. for the ten years ending 1912; in Asia, Africa, and South America also natives prefer wheaten flour to their ordinary diet, and the demand for this flour will advance as the material prosperity of the people improves. It is fortunate, therefore, that vast tracts of virgin land are available for wheat-growing in Canada, Argentina, Australia, and Siberia, and that the old-world granary of Mesopotamia, after centuries of neglect and misrule, will again provide abundant supplies of food for mankind. The rice-lands in Eastern countries with their teeming populations have, on the other hand, nearly all been brought into cultivation, and although lands suitable for rice are available in Africa and America, it seems doubtful whether rice will be cultivated on an extensive scale in these countries.

The quantity of maize produced in the world is probably greater than that of wheat, and the demand for this grain is constantly increasing. Maize is a prolific crop: it is estimated that it takes a little more than half of the acreage laid down to wheat to provide the same yield of maize. The United States contribute at present about 70 per cent. of the total world's production; Argentina, Brazil, Mexico, Peru, India, Egypt, Russia, Rumania, Hungary, and Italy are also large producers, and British South Africa, with a suitable climate for this crop, promises in the future to supply large quantities of maize. In

Europe and North America maize is chiefly used for feeding live-stock, and the wonderful development of the pork industry of the United States is directly related to the maize crop. In parts of South America, Africa, Asia, and of Southern and Eastern Europe, maize provides food for the people. Although corn-flour is largely eaten in all civilised countries, this flour alone cannot be made into a light porous loaf, as can wheaten flour, owing to the difference in the character of its gluten.

Barley is an important crop in Europe, especially in Russia and Germany; it is also extensively cultivated in North America, Northern Africa, Japan, China, India, and Asiatic Turkey. The annual production in the world cannot be short of 50,000,000 tons. In Europe and North America the grain provides food for cattle, and the best qualities are also largely used by distillers and brewers, the by-products which result forming valuable food for cattle. Barley is eaten, to some extent, by the inhabitants of Northern Africa, and also in parts of Asia; its principal use is, however, as fodder for cattle. During the war, barley meal was used in most of the European countries for admixture with wheaten flour in the manufacture of bread.

The annual production of oats in the world is estimated at about 65,000,000 tons; oats are raised principally in Europe and North America, mainly as food for cattle. An increasing quantity of oatmeal and other preparations of this grain is now being consumed throughout the world; in 1918 the United States exported over 150,000 tons of oatmeal, rolled oats, etc.

Millets are grown extensively in Asia, Africa, and also in Russia and the Balkan States. It is not possible to frame any reliable estimate of the quantity of this grain produced in the world. In India 52,000,000 acres are devoted to millets, and the supply of human food obtained from this source is only of less importance than rice. In China also there is a large cultivation, and in Japan the estimated outturn of grain is 500,000 tons. The production in Egypt is 250,000 tons, and millets are grown in many other parts of Africa. The production in Russia in 1912 was about 2,500,000 tons. During the same year

Russia produced 1,200,000 tons of buckwheat. France and the United States each produced about 400,000 tons of this grain, which is also grown in other parts of the world.

World's Consumption of Cereals

The following statement shows the average consumption per head of population, in certain countries, of wheat, rye, barley, oats, and maize for the five years 1909–13.

Country.	Wheat. *lb.*	Rye. *lb.*	Barley. *lb.*	Oats. *lb.*	Maize. *lb.*	Total. *lb.*
United Kingdom	360	3	115	181	99	758
France	493	64	61	292	59	969
Belgium	505	195	123	204	128	1,155
Netherlands	263	241	113	140	201	958
Denmark	245	500	409	622	238	2,014
Sweden	158	251	114	433	17	973
Russia	180	244	72	155	18	669
Spain	340	66	156	41	98	701
Italy	370	8	13	37	179	607
Germany	191	323	213	269	27	1,023
Austria	217	213	121	174	73	798
Hungary	310	84	120	105	479	1,098
Rumania	181	3	22	70	481	757
Canada	755	15	226	1,339	211	2,546
United States	319	18	81	349	1,564	2,331
Argentina	354	3	14	28	408	807
Japan	31	—	87	3	4	125
Egypt	191	—	46	—	311	548
Australia	328	—	28	116	125	597

The above statement has been prepared from the Statistical Notes published by the International Institute of Agriculture, Rome. The consumption covers not only human food, but also cereals required for feeding livestock, and for industrial purposes ; seed requirements are, however, excluded.

The consumption of rice in the Western countries of Europe and in America may be estimated at between 8 and 10 lb. per capita ; the pre-war average in the United Kingdom was 8 lb., but latterly it has been twice as great. In Italy and Spain, where rice is grown, the consumption is over 25 lb., and in Egypt it is over 50 lb. In Japan, where rice is the staple food of the people, the consumption is about 400 lb. In Italy, Russia, Egypt, and Japan millets and buckwheat are largely consumed.

There are no estimates showing the quantity of cereals required for human consumption in the countries mentioned above. It may be estimated, however, that the average consumption per capita is 4 cwts. of grain, equivalent to about 300 lb. of flour or meal. The quantity of flour or meal obtained from grain varies according to the quality of the grain; it is however generally estimated that 133·3 lb. of wheat or barley, 153·8 lb. of rye, 166·6 lb. of oats, and 117·6 lb. of maize are required to produce 100 lb. of meal or flour. The amount of cereals consumed in different countries varies considerably: in France and Belgium, for instance, the mass of the people eat more bread and farinaceous food than those in England and America, who are accustomed to a more liberal meat diet. More wheaten flour is consumed in France and Belgium than in any other country, the high rate of consumption of wheat in Canada being due to the fact that in the past this grain was often given to cattle. An examination of the statement given above shows that wheat is the principal cereal consumed in the Western countries of Europe, whereas in the Central and Northern countries generally rye is more largely eaten than wheat. In Rumania wheat is extensively grown for export, maize being the chief diet of the people.

Source of European Supplies of Cereals

The following table shows the average production of cereals in certain countries of Europe for the five years 1909–13 (1,000 tons).

Country.	Population.	Wheat.	Rye.	Barley.	Oats.	Maize.	Rice.	Millets, buck-wheat, spelt.	Total.
United Kingdom .	45,400,000	1,623	20	1,422	2,998	—	—	—	6,063
France .	40,000,000	8,644	1,245	1,049	5,156	566	—	400	17,060
Belgium .	7,500,000	405	580	94	618	—	—	—	1,697
Denmark .	2,800,000	145	451	543	776	—	—	—	1,915
Spain .	20,000,000	3,550	702	1,626	422	674	350	3	7,327
Italy .	35,000,000	4,989	135	220	536	2,548	500	130	9,058
Germany .	65,000,000	4,156	11,325	3,344	8,642	—	—	400	27,867

The average production, surplus of imports over exports, and consumption per capita of cereals in

each country for the five years 1909–13, were as follows :

	Average production.	Average surplus of imports over exports.	Average consumption.
	cwts.	*cwts.*	*cwts.*
United Kingdom	2·6	4·3	6·9
France	8·5	1·1	9·6
Belgium	4·5	6·2	10·7
Denmark	13·7	5·3	19·0
Spain	7·3	·4	7·7
Italy	5·1	1·1	6·2
Germany	8·5	1·6	10·1

Continental countries as a rule protect their agricultural industries by imposing import duties on cereals. In Germany the import duty on a quarter (8 bushels) of wheat was 11*s.* 10*d.* ; in France 12*s.* 3*d.* ; and in Italy 13*s.* The import duties in flour were on a higher scale. Belgium and Denmark admitted wheat free of duty.

The above table shows how dependent this country is on imported grain. With the exception of Norway and Finland, no other country in Europe is so dependent on outside supplies. Denmark, in proportion to her population, imports a greater quantity of grain than the United Kingdom ; this is due, however, to the fact that her live-stock industry is relatively much more highly developed. The following table shows the number of live-stock in the two countries in 1912.

	Cattle.	Sheep.	Pigs.
	No.	*No.*	*No.*
United Kingdom	11,914,635	28,967,495	3,992,549
Denmark	2,253,982	726,879	1,467,822

The estimated number of poultry in Denmark was 13,000,000, for the feeding of which a large quantity of cereals would be required.

The number of live-stock in the two countries for every thousand inhabitants is as follows :

	Cattle.	Sheep.	Pigs.
	No.	*No.*	*No.*
United Kingdom	262	638	88
Denmark	804	259	524

In Great Britain for every 100 acres under crops or grass there are on an average 23 head of cattle, and in Ireland 34 ; in Denmark the number is 32, and in Belgium,

before the war, there were 42. Taking cows and heifers only, there are in Great Britain 9·5, and in Ireland 11 to each 100 acres; whereas in Denmark and Belgium, before the war, the number was twice as large as in Great Britain.

The belief appears to obtain in some quarters that the choice of farmers in this country lies between wheat and milk. It has been maintained that the breaking up of grass-lands for cereals will result in the reduction of the number of cattle. This has not been the experience of farmers in Denmark, where there is very little pasturage and yet the head of cattle is, in proportion to the cultivated area, greater than in England. Corn and live-stock are not competitive products, unless cereals are grown on a large scale for sale, leaving no home-grown keep for animals. In Denmark less than 8 per cent. of the cereals grown consists of wheat, whereas in Great Britain the percentage of wheat to other cereals is nearly 30 per cent. Now that the national emergency has passed, and large supplies of wheat are available in Canada and other British Dominions, the question arises whether the cultivation in this country of oats and green crops for feeding stock would not pay better than wheat. In considering the relative advantages of growing wheat or oats, it should be borne in mind that the rates of ocean freight for oats are from 20 to 30 per cent. higher than for wheat, which is a heavier grain. The dairymen in this country rely principally on pasturage during the summer months, whereas in Belgium and Denmark, where pasturage is limited, the farmers by intensive cultivation raise green crops for feeding cattle. For many years before the outbreak of war a decline in the acreage of arable land was a regular feature in the annual returns of agriculture in Great Britain. The reasons generally assigned for the reduction of arable land were the increase in the cost of cultivation, the growing scarcity of qualified labour, and the fall in prices of agricultural produce, due to the intensity of foreign competition. There is less risk and outlay involved in farming grass land, and less labour is required; it is admitted, however, that a larger head of stock cannot thus be carried, and in fact that the number may be less than under a mixed system of farming.

The following table shows the average acreage under

cereals and the average number of cattle and sheep in the United Kingdom over a period of years.

Period.	Wheat.	Barley.	Oats.	Total.	Number of cattle.	Number of sheep.
	Acres.	*Acres.*	*Acres.*	*Acres.*		
1873 .	3,670,000	2,574,000	4,198,000	10,442,000	10,153,000	33,982,000
1884–88	2,543,600	2,349,100	4,314,900	9,207,600	10,614,000	29,351,000
1894–98	1,853,600	2,232,500	4,335,900	8,422,000	10,924,000	30,467,000
1904–08	1,675,000	1,903,300	4,206,900	7,785,200	11,660,000	29,747,000
1909–13	1,888,300	1,847,300	4,061,200	7,796,800	11,849,000	30,016,000
1914–18	2,238,700	1,737,400	4,529,300	8,505,400	12,298,000	28,239,000
1914 .	1,906,000	1,873,000	3,899,000	7,678,000	12,184,000	27,904,000
1918 .	2,793,000	1,839,000	5,605,000	10,237,000	12,451,000	28,849,000

Although in 1917 the cultivated area in Ireland represented 31 per cent. of the total acreage under crops and grass in the United Kingdom, her share of the total acreage under wheat was only 6 per cent., of barley 10 per cent., and of oats 30 per cent. Ireland possessed, however, 40 per cent. of the total head of cattle and 13 per cent. of the sheep. In 1918 both the acreage under cereals and the number of cattle in the United Kingdom were greater than in any year for the last thirty-five years. England is one of the few countries in Europe where the number of sheep has been maintained in recent years. In most of the Continental countries sheep have decreased as the area of arable land has increased, and the same tendency is noticeable in the more closely settled districts of Australia and Argentina.

The value of farm and dairy produce imported into the United Kingdom is very large, and much of it comes from Denmark. The total value of imports of eggs, butter, and bacon in 1914, with the share of Denmark in the trade, was as follows:

	Total value of imports.	Share of Denmark.
	£	£
Eggs . . .	8,652,800	2,546,979
Butter . . .	24,014,276	11,038,637
Bacon . . .	18,225,568	9,936,454
Total . .	50,892,644	23,522,070

With closer settlement on the land and more intensive cultivation it should be possible to increase largely the home supplies of farm and dairy produce.

The average net imports of cereals (flour and meal being reduced to grain) into countries in Europe for the five years 1909–13 are shown in the following table :

	Wheat.	Rye.	Barley.	Oats.	Maize.	Total.
	Tons.	*Tons.*	*Tons*	*Tons.*	*Tons.*	*Tons.*
United Kingdom	5,880,000	30,000	1,046,000	963,000	2,047,000	9,966,000
France .	1,188,000	81,000	132,000	433,000	503,000	2,337,000
Belgium .	1,340,000	124,000	330,000	119,000	438,000	2,351,000
Netherlands .	598,000	293,000	241,000	117,000	552,000	1,801,000
Denmark	171,000	208,000	3,000	66,000	298,000	746,000
Norway .	104,000	262,000	99,000	10,000	30,000	505,000
Sweden .	191,000	97,000	—	66,000	42,000	396,000
Spain .	168,000	—	—	—	247,000	415,000
Italy .	1,448,000	16,000	18,000	118,000	368,000	1,968,000
Switzerland	460,000	18,000	25,000	181,000	101,000	785,000
Germany	1,859,000	—	3,245,000	47,000	812,000	5,973,000
Austria .	1,397,000	316,000	91,000	191,000	594,000	2,589,000
Total .	14,804,000	1,445,000	5,230,000	2,311,000	6,032,000	29,822,000

The principal exporting countries of the world for the five years 1909–13 were as follows :

	Wheat.	Rye.	Barley.	Oats.	Maize.	Total.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Russia .	4,467,000	707,000	3,769,000	1,005,000	711,000	10,659,000
Germany	—	671,000	—	—	—	671,000
Hungary.	1,111,000	348,000	252,000	159,000	219,000	2,089,000
Rumania	1,460,000	96,000	390,000	141,000	1,138,000	3,225,000
Bulgaria	302,000	49,000	40,000	1,000	234,000	626,000
Canada .	2,580,000	—	119,000	238,000	—	2,937,000
United States .	2,910,000	24,000	180,000	64,000	924,000	4,102,000
Argentina	2,586,000	7,000	16,000	617,000	2,940,000	6,166,000
British India .	1,349,000	—	226,000	—	20,000	1,595,000
Algeria .	144,000	—	114,000	58,000	—	316,000
Australia	1,345,000	—	2,000	—	—	1,347,000
Total .	18,254,000	1,902,000	5,108,000	2,283,000	6,186,000	33,733,000

The United States and Argentina send large quantities of wheat and flour to countries outside Europe ; in other respects the trade was mainly with Europe. It will be seen that the importing countries in Europe obtained 55 per cent. of their requirements from other European countries, of which Russia supplied 35 per cent. and Rumania 11 per cent. During the war the Western countries of

Europe could not draw on Russia or Rumania; this shortage was, however, largely made good by much heavier imports from the United States and Canada, as the following table will show:

AVERAGE EXPORTS FROM THE UNITED STATES AND CANADA—1914–15 TO 1917–18.

	Wheat.	Rye.	Barley.	Oats.	Maize.	Total.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Canada .	4,712,000	19,000	222,000	663,000	—	5,616,000
United States .	5,576,000	346,000	526,000	1,512,000	1,172,000	9,132,000
Total .	10,288,000	365,000	748,000	2,175,000	1,172,000	14,748,000

In 1917–18, the Union of South Africa exported over 200,000 tons of maize, and Brazil nearly 240,000 tons.

VARIETIES AND QUALITIES OF WHEAT

There are many varieties of wheat grown in the world. All the best wheats grown, however, fall under the group "Common Wheats." The grain of the common bread wheat varies both in colour and quality, and may be either soft or hard. Soft wheat, termed "weak" by the miller, generally yields flour which makes a somewhat small loaf of dense texture; hard wheat, termed "strong," makes a larger and a porous loaf. As flour manufactured from hard wheat will carry a large percentage of moisture, a greater number of loaves of equal weight can be made from a given quantity of this flour than from the same quantity of flour obtained from soft wheat. The dense-eared types with weak grain give a heavier yield per acre than the hard wheats, and on this account they are largely cultivated in England, France, Germany, and in many of the older and closely settled countries. In countries with severe winters, high summer temperature and low rainfall, strong varieties with low yields are grown. The best descriptions of hard red wheat are produced in the United States, Canada, and Southern and Eastern Russia. Generally speaking the question of strength or weakness of grain is dependent on the variety grown, and upon soil and

climate ; high summer temperature and low rainfall favour nitrogen content and flintiness ; cooler and damper climates, on the other hand, favour starch production. It has been maintained that very high yield and superior strength could not be contained in the same variety ; recent experiments made by the Agricultural Departments in India have proved, however, that this view is not correct, as excellent results, both as regards yield and quality, have been obtained from some new types, which have been created by selection and cross-breeding and distributed among the cultivators in India. The average quality of home-grown wheats is low, and as wheats of the highest quality can be produced in England, efforts are now being made to obtain new varieties of prime quality and high yielding capacity. In recent years the standard of excellence of flour has been raised, and there is a constant tendency towards the use of hard red wheats, with the result that the proportion of such wheats now grown in the world is much larger than it was twenty years ago.

Wheats of widely different characteristics are required by British millers, and home-grown wheat is nearly all mixed with Canadian and other foreign wheats, containing a high percentage of nitrogenous matter, to give the right proportion of milling and baking qualities for our bread-eaters. In many mills flour is never made from one straight lot of wheat, sometimes as many as four or five different lots are blended to obtain a well-balanced product. The chief constituents of flour are starch and gluten (albuminoids), which are found in an average proportion of 88 per cent. of starch and 12 per cent. of gluten. The gluten may be as low as 6 or 8 per cent. in soft wheats, and as high as 15 per cent. in hard wheats. The highest gluten content is possessed by the light-amber wheats of the durum group, which are grown extensively in Southern Europe and Northern Africa, and also in North America and Southern Russia. From the flour of this wheat macaroni and similar Italian pastes are prepared. The flour extraction of wheat varies in accordance with the quality of the grain. In America it is estimated that a good sample of Kansas Turkey wheat, a hard winter

wheat, properly milled, will yield products approximating the following percentages: bran 12 per cent., shorts 14 per cent., total flour 72 per cent., which allows 2 per cent. for wastage and evaporation of moisture. Since the middle of the nineteenth century the milling process has been made much more efficient, partly by the substitution of rollers for millstones, and partly by improvements in arrangements for cleaning the grain and sorting out the various products obtained at different stages of the process. In normal times the average yield of flour from wheat in England is about 70 per cent., with about 28 per cent. of bran and pollards in nearly equal proportions. Usually two kinds of flour are made from one mixture. In Hungary and other parts of the Continent, where a dark flour can be sold or mixed with rye flour, yields as high as 75 and 78 per cent. are obtained, and several grades of flour are made. During the war the flour extraction prescribed in this country varied with the quality of the wheat, but at first 81 per cent. was the standard, raised successively to 83, 88, and finally to 90 per cent. for some qualities. In Algeria the flour extraction for soft wheat was at first fixed at 74 per cent., and for hard wheat at 81 per cent. From March 1, 1917, the flour extraction in Germany was as high as 94 per cent.

The Production and Distribution of Wheat in the World

Wheat has a range of cultivation in the world, both as to elevation and latitude, greater than that of any other cereal. It is now grown successfully in the tropics and near the Arctic Circle. According to the estimates framed by the International Institute of Agriculture, Rome, the average area under wheat for the five years 1909–13 was about 250,000,000 acres, and the average yield of grain about 100,000,000 tons. These estimates do not include, however, the statistics for Serbia, Albania, Montenegro, Thrace, Greece, Finland, and Portugal in Europe, and only relate to returns from a part of Asiatic Russia and from India and Japan in Asia, to the Union of South Africa, Algeria, Tunis, and Egypt in Africa, and to the United

States, Canada, Argentina, Uruguay, and Chile in America. The European States omitted from the returns produce close on a million tons of wheat. China, Persia, and Asiatic Turkey are all large producers, but unfortunately no reliable statistics are available. It has been estimated that 7,500,000 acres are devoted to wheat in the Ottoman Empire, and the production may be estimated at over 3,000,000 tons. Before the war Turkey was exporting both wheat and flour, and with more settled conditions and improved communications a great expansion may be expected in this direction. The Persians, like their neighbours in Turkey, are largely bread-eaters, and not only supply their own requirements, but are able to export small quantities of wheat. Wheat has been grown in China from the most ancient times, and the production must be very large, as it has been estimated that one-third of the population of China does not eat rice. Wheat is grown in nearly every province in China, and is the staple food in the north. Travellers in many parts of China have recorded the fact that fields of wheat are the most common feature in the landscape. According to American Consular reports, Manchuria raises about 10,000,000 bushels of wheat, and is capable of producing 300,000,000 bushels. Wheat is grown extensively in Morocco, and in normal times the exports exceed 30,000 tons ; in Abyssinia wheat is the staple food of the people. In Mexico and Brazil wheat is cultivated, and the production is increasing. It may be fairly estimated that wheat throughout the world at the outbreak of the war occupied 275,000,000 acres, and supplied about 4,000,000,000 bushels or 110,000,000 tons of grain. After deducting the seed requirements, which may be estimated at 11,000,000 tons, on the basis of 100 lb. of seed to the acre, there would be available as food approximately 100,000,000 tons of wheat, equivalent to about 75,000,000 tons of flour.

In the Northern Hemisphere the wheat harvest begins in India in March, and continues in one country or other until September, the largest area being reaped in July and August. In December and January, Australia and Argentina gather their harvests. The world's harvest is usually reckoned as being finished in February.

The following table shows the production, imports, exports, and consumption of wheat in certain countries for the five years 1909–13. (The trade in flour, expressed in its equivalent weight of grain, is included.)

Country.	Average production.	Average surplus of imports over exports.	Average surplus of exports over imports.	Average consumption.
	Tons.	*Tons.*	*Tons.*	*Tons.*
United Kingdom	1,621,000	5,880,000	—	7,501,000
France	8,644,000	1,188,000	—	9,832,000
Belgium	405,000	1,344,000	—	1,749,000
Netherlands	131,000	598,000	—	729,000
Denmark	145,000	171,000	—	316,000
Norway	8,000	104,000	—	112,000
Sweden	220,000	191,000	—	411,000
Russia in Europe, excluding Finland	18,180,000	—	4,467,000	17,713,000
Russia in Asia, 9 Governments	4,000,000	—		
Spain	3,550,000	168,000	—	3,718,000
Italy	4,989,000	1,448,000	—	6,437,000
Switzerland	90,000	460,000	—	550,000
Germany	4,156,000	1,859,000	—	6,015,000
Austria	1,655,000	1,397,000	—	3,052,000
Hungary	4,621,000	—	1,111,000	3,510,000
Rumania	2,389,000	—	1,459,000	930,000
Bulgaria	1,190,000	—	301,000	889,000
Canada	5,571,000	—	2,580,000	2,991,000
United States	18,688,000	—	2,910,000	15,778,000
Argentina	4,282,000	—	2,586,000	1,696,000
Uruguay	195,000	—	35,000	160,000
Chile	609,000	—	65,000	544,000
British India	9,573,000	—	1,349,000	8,224,000
Japan	657,000	110,000	—	767,000
Union of South Africa	148,000	161,000	—	309,000
Egypt	928,000	212,000	—	1,140,000
Algeria	952,000	—	143,000	809,000
Tunis	169,000	20,000	—	189,000
Australia	2,241,000	—	1,345,000	896,000
New Zealand	211,000	—	20,000	191,000
Total	100,218,000	15,311,000	18,371,000	97,158,000

The average production of wheat in Europe for the five pre-war years, assuming that the production of the European countries not shown in the above table was 1,000,000 tons, amounted to 53,000,000 tons. The only countries in Europe producing surplus wheat for export were Bulgaria, Rumania, Serbia, Hungary and Russia. The remaining countries in Europe imported 14,804,000

tons of wheat, of which 7,338,000 tons were supplied by the countries mentioned above, and 7,466,000 tons were obtained from over-sea sources, mainly from Canada, the United States, Argentina, Australia, and British India. During the war the surplus wheat from Russia could not be exported, and owing to the disturbed condition of the country it is probable that production has been much reduced. Since the outbreak of the war a great change in the land tenure has occurred in Russia, Rumania, and Hungary. Before the war the land in Russia was largely held in communal or in private ownership, and agriculture on the privately owned land was of a more advanced character, and gave a higher yield. Commercial farming on a large scale had made considerable progress, and wheat cultivation had been rapidly increased. In 1904 it was estimated that 17,627,000 acres of the wheat acreage was in private hands, and 26,126,000 acres in communal ownership. Under the communal system the land is held in common ownership by the villages, and is distributed at certain intervals among the members of the community for individual cultivation. The redistribution of the land tends to discourage high cultivation and manuring, and there was a growing tendency for the richer peasants to rent land from their poorer neighbours. Since the revolution took place in Russia the peasants have apparently taken possession of the land, and if the large farmers, who worked on modern lines, are eliminated, it must follow that production will decline, as the peasants will at first be poorly equipped with capital and machinery. In Rumania and Hungary the large estates have to a great extent been broken up into small farms. Eventually the productivity of the land will undoubtedly be enhanced by the new system of farming, but it will be interesting to see what immediate result the change in the ownership of the land will have on the production of cereals on a large scale for export. It remains to be proved whether the small farmer can afford to grow wheat in these countries to the same extent as the late landowners who farmed on an extensive scale, and made wheat their main crop.

The following table shows the average production of wheat for the four years 1914–17, compared with the

five years 1909–13, in Allied and Neutral countries in Europe :

Name of country.	1909–13. Tons.	1914–17. Tons
United Kingdom	1,621,000	1,772,000
France	8,644,000	5,814,000
Netherlands	131,000	143,000
Denmark	145,000	164,000
Norway	8,000	9,000
Sweden	220,000	234,000
Spain	3,550,000	3,744,000
Italy	4,989,000	4,466,000
Switzerland	90,000	106,000
Total	19,398,000	16,452,000

France and Italy both suffered by the invasion and occupation of their territories by the enemy. Outside Europe there was a great expansion in wheat cultivation, as the following statement will show :

Name of country.	1909–13. Tons.	1914–17. Tons.	1918. Tons.
Canada	5,574,000	7,379,000	5,724,000
United States	18,688,000	21,799,000	25,009,000
Argentina	4,282,000	3,579,000	5,950,000
British India	9,573,000	9,448,000	10,337,000
Australia	2,241,000	3,129,000	3,134,000
Total	40,358,000	45,334,000	50,154,000

The acreage under wheat in the above-mentioned countries in 1918 had increased by 31,000,000 acres, and was 27 per cent. larger than the average acreage for the five pre-war years. There is at the present time a sufficiency of wheat, even without the help of Russia, to meet the requirements of the world, and with an extended area under cultivation in many countries there should be no danger of shortage in the immediate future. The question of the transport and distribution of the crops is, however, a difficult one, and freight charges will be high for a long time.

The area under wheat, production, and yield per acre in various countries of the world during three periods are given in the following table. The statement is incomplete, as statistics regarding several wheat-growing countries are not available. It may be estimated, however, that the

countries not represented produce about 10 per cent. of the total world's production.

Name of country.	Area sown. Million acres.			Total harvest. Million bushels.			Yield per acre. Bushels per acre.		
	1881–90.	1891–00.	1909–13.	1881–90.	1891–00.	1909–13.	1881–90.	1891–00.	1909–13
United Kingdom	2·7	2·0	1·9	76	60	60	28	30	32
France	17·2	17·1	16·0	301	305	317	17	18	20
Belgium	0·6	0·5	0·4	18	16	15	30	33	37
Netherlands, Denmark, Norway, Sweden, Switzerland	0·6	0·6	0·6	17	18	22	28	30	36
Russia-in-Europe	30·2	36·2	61·2	244	300	666	8	8	11
Portugal	0·7	0·7	0·9	7	7	8	10	10	9
Spain	9·0	9·1	9·5	100	92	130	11	10	13
Italy	11·3	11·3	11·6	118	123	183	10	11	16
Germany	4·7	4·9	4·8	104	125	153	22	25	32
Austria	2·7	2·7	3·0	43	43	60	16	16	20
Hungary	6·8	8·2	9·0	118	143	169	17	17	19
Rumania	3·4	3·7	4·6	42	52	88	12	14	19
Bulgaria	2·4	2·4	2·9	35	35	44	15	15	15
Serbia, Greece, Turkey-in-Europe	3·6	3·6	3·6	40	40	40	11	11	11
Total Europe	95·9	103·0	130·0	1,263	1,359	1,955	13·1	13·2	15
India	26·7	25·2	29·2	259	243	351	10	10	12
Russia-in-Asia, 9 Governments	8·4	10·6	9·5	74	100	120	9	9	12
Japan	1·0	1·1	1·2	13	19	24	13	17	20
Canada	2·3	3·1	10·5	38	55	204	16	18	19
United States	37·1	43·1	47·1	427	559	685	12	13	14
Argentina	2·0	5·7	15·0	24	65	147	12	11	10
Uruguay	0·4	0·6	0·8	4	6	6	10	10	7
Chile	0·9	1·0	1·0	12	14	21	13	14	21
Union of South Africa	0·2	0·3	0·7	2	2	6	7	7	9
Egypt	1·2	1·3	1·3	12	13	34	10	10	26
Algeria	3·1	3·2	3·5	21	24	35	7	8	10
Tunis	0·8	1·0	1·3	5	6	6	6	6	5
Australia	3·2	4·1	7·6	27	30	90	8	7	12
New Zealand	0·3	0·3	0·3	8	7	7	25	25	25
Total	87·6	100·6	129·0	926	1,143	1,736	10·5	11·3	13·4
Grand Total	183·5	203·6	259·0	2,189	2,502	3,691	11·9	12·0	14·1

One of the most important features in the above statement is the rapid increase in the area under wheat in European Russia. The average area sown advanced from 36,000,000 acres between 1891–1900 to 61,000,000 acres between 1909–13, and the average production rose from 300,000,000 bushels to 666,000,000 bushels. The extension

of wheat cultivation had, moreover, by no means reached its limit when the outbreak of war checked further progress. The returns from Italy are also remarkable, as the increase of 60,000,000 bushels in the third over the second period was almost entirely due to the increase in the yield per acre. With the exception of Portugal, Serbia, Greece, and Turkey, regarding which countries reliable statistics are not available, every country in Europe obtained a higher yield per acre. Compared with the yields of 42 bushels per acre in Denmark, 37 bushels in Belgium, and 32 bushels in England and Germany, the average yield of 15 bushels per acre for the whole of Europe is low, but with more scientific methods of agriculture and improved seed there can be little doubt that better results will be obtained in the backward countries.

Outside Europe the greatest advance in wheat-growing has been made in the following countries:

	1891–00. Area sown. Million acres.	1909–13. Area sown. Million acres.	1918. Area sown. Million acres.
Canada	3·1	10·5	17·3
United States	43·1	47·1	58·9
Argentina	5·7	15·0	17·9
India	25·2	29·2	35·5
Russia-in-Asia	10·6	9·5	14·5 [1]
Australia	4·1	7·6	11·0
Total	91·8	110·9	155·1

[1] *Area sown in* 1915.

There was a general improvement in the average yield per acre, which is, however, still very low in most of the countries. The crops in Australia suffer from drought, and in Argentina from drought and locusts, and in both these countries the average quantity of seed sown is only a little more than one bushel to the acre. In India rust is the chief enemy, and accounts for the low average yield. Rust is the most widespread and serious disease from which wheat suffers; neither spraying nor seed treatment have been successful in checking the disease. Rust-resistance varies greatly geographically, and depends also on the kind of rust: varieties resistant in one locality may not be so in another. Known rust-proof varieties are generally poor

yielders, but by selection and hybridisation some progress has been made in raising good-cropping rust-proof types of wheat in different countries.

That there has been a great improvement in wheat-growing is evident from the fact that, whereas the total area sown advanced by less than 25 per cent. in the third over the second period, the total production rose by nearly 48 per cent. In 1898 the late Sir William Crookes estimated that the wheat-growing countries could only add 100,000,000 acres to the wheat area of the world, and this additional area would produce 1,270,000,000 bushels, just enough to supply the world's requirements up to 1931. About half the allotted period had elapsed in 1913, and although only 50,000,000 acres had been added to the wheat area, the production had increased by 1,191,000,000 bushels, nearly equal to the total production estimated for the additional 100,000,000 acres. Since the outbreak of the war, further extensions, amounting to nearly 50,000,000 acres, have been added, and vast areas of new land are still available in Canada, Argentina, Brazil, Australia and Siberia. In the United States and European Russia further extensions can be made, and in Asiatic Turkey and Northern Africa under settled conditions and with improved communications much larger areas will be brought into cultivation. When the forecast was made in 1898 it was apparently not recognised that the North Western Provinces of Canada possessed some of the most favourably situated wheat-growing lands in the world, and that the great sheep-runs of Australia and Argentina, with their scanty rainfall, were also suitable for wheat-growing.

It is difficult to estimate the total area of new land in the world which could be made available for wheat-growing; it must, however, be far in excess of the area now devoted to wheat. In Australia it has recently been estimated that the area, with over 10 inches of rain in the growing season, available for grain in New South Wales, Victoria, South Australia and Western Australia, is nearly 50,000,000 acres. There are also immense areas of good land situated in the drier zones of the four States mentioned above, which under irrigation or with improved methods of cultivation and improvement in drought-resisting wheats will

eventually come under cultivation. In Queensland and the Northern Territory there are great areas of land, both within and outside the tropics, where climate and soil are quite suitable for wheat-growing. In South America new lands suitable for wheat-growing probably equal those available in Australia, and Canada and Siberia will eventually provide even larger areas for wheat. Not only are there large reserve areas of land available to meet the growing requirements of the world, but the average yield per acre is being steadily improved. Under ordinary agriculture and with improved types of drought and rust resisting wheats there is every reason to expect that the present average yield of 13 bushels per acre will be doubled, and with intensive cultivation the yield could be trebled. The fears expressed in some quarters that there will be a wheat crisis before the end of this century are without foundation. It has been predicted that the maximum world's production of wheat will be 6,000,000,000 bushels, and that the earth may in the end be able to feed permanently 1,000,000,000 wheat-eaters. With an average yield of 26 bushels to the acre the existing wheat area of 300,000,000 acres would produce 8,000,000,000 bushels of wheat.

Production and Trade in the Chief Countries of the World

United Kingdom.—The following statement shows the wheat production and the quantities and values of wheat and flour imported since 1861.

Period.	Average annual production of wheat.	Wheat.		Flour.		Percentage of flour to total imports of wheat and flour.	Average value of wheat per ton.
		Average imports.	Average value.	Average imports.	Average value.		
	Tons.	*Tons.*	£	*Tons.*	£		£ s. d.
1861–75 .	3,000,000	1,724,000	20,087,000	252,000	4,041,000	12·7	11 13 0
1876–90 .	2,272,000	2,791,000	26,343,000	647,000	8,865,000	18·8	9 8 9
1891–05 .	1,520,000	3,720,000	25,540,000	971,000	9,424,000	20·7	6 17 3
1906–10 .	1,575,000	4,843,000	39,550,000	614,000	6,493,000	12·6	8 3 3
1911–14 .	1,628,000	5,125,000	43,484,000	528,000	5,673,000	9·3	8 9 8
1915–17 .	1,766,000	4,669,000	71,275,000	579,000	11,783,000	11·0	15 5 3

There was a great fall in the price of wheat during the latter half of the nineteenth century, brought about by the development of new wheat lands abroad, and the remarkable reduction in the cost of seaborne transport. An average level of about 50*s.* a quarter was maintained over long periods up to 1874, and then for ten years the average was about 45*s.* After this the price fell rapidly until in 1894 a minimum of 22*s.* 10*d.* was reached. For about ten years prices ruled low, and then there was a recovery, and the average price in 1909 was 36*s.* 11*d.* In 1910–11 the price fell to 30*s.* 11*d.*, and in 1913 the average price was 32*s.* 4*d.* After the outbreak of war, owing to the difficulties of transport, there was an enormous rise in prices. In 1873, 3,700,000 acres were devoted to wheat in the United Kingdom, but with the fall in prices land rapidly went out of cultivation, and in 1904 the acreage sown was only 1,400,000, the lowest level reached. For the five pre-war years the average area under wheat was about 1,900,000 acres; during the war the wheat acreage was largely extended under the stimulus of the Corn Production Act, until in 1918 the acreage was 2,800,000. Agriculture is one of the most essential industries, as the permanent material prosperity of a nation depends largely on the full development of the agricultural resources of the country. Unfortunately farming in this country did not prosper during the period when large and cheap supplies of corn, meat, and dairy produce were imported from abroad, with the result that between 1871 and 1913 the area under arable cultivation in Great Britain was reduced by 4,000,000 acres, or by more than one-fourth, and a large proportion of the rural population either emigrated or moved into already congested industrial centres in search of employment.

The average consumption of wheat (imported flour expressed in its equivalent weight in grain) in the United Kingdom for the five years 1909–13 was 7,500,000 tons, of which 20 per cent. was produced in the country, and the balance imported. The sources of our wheat supplies are varied, but those countries which send substantial and regular contributions are few.

The shares of the principal countries from which the

United Kingdom draws supplies of wheat, are shown in the following table; flour, expressed in its equivalent weight in grain, is included:

	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.
Canada	13·1	16·4	17·2	17·1	16·9	21·9	22·5	29·7	23·5	23·7	21·3	25·1
Australia	7·4	5·3	9·2	11·5	13·0	10·4	8·7	10·5	0·1	3·7	10·5	4·6
India	15·8	2·7	12·9	15·1	18·0	20·5	15·3	9·1	13·7	4·9	2·5	0·8
Total from British Empire	36·4	24·5	40·0	44·1	48·5	53·1	46·5	50·6	37·5	32·6	34·6	30·6
United States	28·8	36·3	22·2	15·2	17·9	20·9	34·8	35·3	47·2	63·0	58·7	52·3
Argentina	19·0	29·2	17·8	12·8	13·3	15·3	12·3	5·6	12·0	4·0	6·1	15·5
Russia	9·9	4·7	15·8	24·3	16·2	7·3	4·1	6·3	0·8	—	0·1	—
Total from Foreign Countries	63·6	75·5	60·0	55·9	51·5	46·9	53·5	49·4	62·5	67·4	65·4	69·4

The outstanding feature of the trade during the war was the great increase in the imports from the United States.

The imports of wheaten flour since 1909, with the principal sources of supply, have been as follows:

	1909.	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
From British Empire	129,200	160,000	188,100	235,500	225,400	173,800	168,500	236,800	290,400	366,300
Foreign countries	423,300	338,000	315,100	273,900	372,900	329,100	355,000	261,100	426,500	951,600
Total	552,500	498,000	503,200	509,400	598,300	502,900	523,500	497,900	716,900	1,317,900
From Canada	103,000	139,200	163,400	200,200	208,400	161,300	168,000	211,300	197,700	278,200
Australia	26,100	20,400	22,200	34,500	17,500	12,400	100	25,000	92,500	84,000
France	26,700	21,900	20,000	18,500	15,000	18,200	3,200	—	—	—
Germany	29,300	29,400	14,100	18,500	22,800	10,800	—	—	—	—
Austria-Hungary	5,400	6,200	5,300	5,800	4,900	2,800	—	—	—	—
United States	346,400	251,400	250,800	201,100	307,800	277,900	337,000	259,100	402,100	898,200
Argentina	4,200	5,000	4,400	5,000	9,500	2,900	4,400	800	800	100
China	—	—	—	—	—	—	—	—	5,800	46,500

The United States and Canada are the principal contributors, followed by Australia; before the war France and Germany sent fairly large quantities of flour. During the last ten years the milling industry in the United Kingdom has been greatly developed; the average quantity of wheat imported between 1896–1900 was 3,332,000 tons,

whereas the average imports for the five years 1909–13 amounted to 5,166,000, an increase of 1,834,000 tons. The imports of flour fell, however, from an average of 1,055,000 tons in the earlier period to 532,000 tons in the later period. In 1917, owing to the question of freight, imports of flour were above the average of the ten preceding years, whilst in 1918, they were greatly in excess of the average for 1896-1900. At one time flour milling was carried on at the principal centres of production, but the great development in the seaborne trade, and low freights, led to the establishment of flour mills in many of the chief ports in this country, such as London, Liverpool, Hull, Glasgow and Leith, where most of the wheat is now dealt with. The average quantity of wheat milled in the United Kingdom during the five years 1909–13 was about 6,800,000 tons, which, on the basis of 70 per cent. of flour, would yield about 4,800,000 tons of flour, 900,000 tons of bran, and about the same quantity of offals. The development of the milling industry is a most satisfactory feature in the trade of the country, as not only does the industry provide employment for capital and labour, but the by-products produced in the country are of great value to the farmers. Unfortunately in pre-war years these by-products were extensively exported to Denmark and Germany. The export trade in flour is not of great importance: in 1913 it amounted to about 80,000 tons, valued at £856,000, the chief customers being Russia, Norway, the Canary Islands, Egypt and Malta. There is a considerable export trade in biscuits, worth £1,561,000 in 1913; in 1917 the value of this trade was £1,752,000, but the volume was 20 per cent. less than in 1913.

Canada.—The rapid development of wheat-growing in Canada is reflected in the following statement.

Period.	Acreage.	Production. Tons.
1881–90	2,300,000	1,000,000
1901–10	5,900,000	2,950,000
1909–13	10,522,000	5,571,000
1914–17	13,771,000	7,379,000
1918	17,344,000	5,724,000

Though wheat is grown in nearly every province the great wheat belt is the western prairie, and the finest wheat

region is the rich valley of the Saskatchewan, where the grain grows to perfection, and the yield averages over 26 bushels to the acre. On the prairie lands, which were first taken up, wheat is being grown year after year without rotation and without manure. In time this must lead to soil exhaustion, but there are vast tracts of land still available, the land area of the three Prairie Provinces amounting to 446,000,000 acres. The further north wheat is grown, up to a certain limit, the better it is. The bulk of the prairie wheat is spring sown, and the chief dangers with which the farmer has to contend are hail in August and early autumn frost. The prevalence of smut is another drawback, which lowers the yield and value of the grain.

The average exports of wheat and flour for the five years 1909–13 were 2,580,000 tons of grain, and for the four years 1914–17, 4,712,000 tons. The United Kingdom takes nearly the whole of the grain, and about two-thirds of the flour exports. In 1913 the exports of grain amounted to 2,100,000 tons, and of flour to 350,000 tons; the corresponding figures for 1916 were 3,800,000 tons of grain and 435,000 tons of flour. Canada also supplies British South Africa, the West Indies, Denmark and Norway with flour.

Australia.—Wheat is the most important farm crop in Australia; approximately half the cultivated area is under wheat. The area under wheat is, however, small retively to the area suitable and available for the cultivation of this crop. The question of the available land and the limits of profitable cultivation was closely studied after the outbreak of war, and it has been estimated that the present average production of 103,000,000 bushels in the four principal producing States, New South Wales, Victoria, South Australia, and Western Australia, could be increased five-fold. In addition Queensland has large areas which will undoubtedly be cultivated in wheat as the country develops. The average yield of wheat per acre in Australia is low, in New South Wales the average is under 11 bushels, and in South Australia, where the crop frequently fails to mature, the average yield is only 8 bushels. With such small returns wheat only pays in Australia because of the low cost of production. Actual figures of the cost of

growing wheat on large farms in districts of less than 20 inches mean annual rainfall have shown that the crop can be sown and harvested for from 21*s.* to 23*s.* per acre, yielding 12 bushels. The quality of the wheats grown in Australia is not equal to the hard Canadian wheats, but the grain is of even grade, and has good milling qualities.

The following statement shows the progress made in wheat cultivation in Australia.

Period.	Acres under wheat.	Production.
		Tons.
1860–1	182,000	70,000
1881–90	3,200,000	720,000
1908–09 to 1912–13 . .	6,791,000	2,241,000
1913–14 to 1916-17 . .	10,727,000	3,129,000

In 1916–17 the production was 4,139,000 tons. The average quantity exported during the five pre-war years was 1,345,000 tons. During the war large stocks of wheat accumulated in Australia as shipping was not available for its transport. In normal times the United Kingdom takes over 70 per cent. of the total exports of grain, and about 15 per cent. of the flour. Australia supplies flour to South Africa, Portuguese East Africa, the Straits Settlements and the Philippine Islands. In 1913 it was estimated that 37,000,000 bushels, or about 1,000,000 tons of wheat, were milled in Australia.

India.—Wheat is grown in all the provinces of India, but principally in the north-western part of the Indo-Gangetic plain, and in the Central Provinces, Central India and Bombay. About 35 per cent. of the total area is under irrigation either in whole or in part.

The area under wheat, and the production since 1891, are shown in the following table :

Period.	Average area under wheat.	Average production.
	Acres.	*Tons.*
1891–1900	25,200,000	6,200,000
1905–9	28,000,000	8,500,000
1909–13	29,200,000	9,570,000
1914–17	31,070,000	9,440,000
1918	35,470,000	10,330,000

In recent years the extension of irrigation in the Punjab has brought into cultivation large areas of land.

The large increase in the cultivation in 1918 was due, however, to the substitution of wheat for other crops. In Upper Burma, especially in the Shan States, land suitable for wheat is available, and will be cultivated when communications are improved and settlers attracted to the land. There is no immediate prospect of largely extending the wheat area in the principal wheat districts of India, where most of the land is cultivated, except by substituting wheat for other crops; the production can, however, be increased by improved methods of cultivation and by employing improved strains of wheat. The introduction on a large scale of the improved Pusa wheats, which are rust-resisting, and give a greater yield than some of those at present grown, will in time increase the production. Wheat and barley are often grown together, and consequently the wheat shipments frequently carry a percentage of barley. Under the terms of the Indian wheat contract of 1907, the admixture of barley was limited to 2 per cent. In recent years a great improvement has been made in shipping grain free from dirt, but the 2 per cent. allowance of barley is sometimes exceeded. Soft wheats are largely grown in India for export; for local consumption hard wheats are preferred. In the drier districts the durum varieties are cultivated, and a few hard winter wheats are to be found in the North. The substitution of superior types of wheat for the soft wheats now grown would not only meet the local demand, but also the requirements of the export trade. The exports of wheat from India, which average less than 15 per cent. of the total production, are influenced by the yield of other food crops, and in times of scarcity the exports fall away. Owing to the failure of the monsoon rains in 1918, wheat is being imported into India from Australia.

Between 1909–13 the exports of wheat and flour averaged 1,349,000 tons of grain. The United Kingdom was the best market for the grain; Continental countries also drew supplies from India. In 1913–14, 80,000 tons of flour were exported, principally to Eastern countries. The flour-milling industry in India is making good progress, but the bulk of the wheat consumed locally is converted into flour in the primitive native mills, and the flour

extraction is much greater than is customary in Western countries. The consumption of wheaten flour in India is increasing.

Mesopotamia.—This country is one of great promise for cereal production. Before the war wheat and barley grown in Mesopotamia were shipped from Basra. The volume of the trade was not large, and it was carried on under great difficulties. Plans had been prepared for constructing important irrigation works which would have brought large areas of land into cultivation. Under Turkish rule, however, little progress had been made in carrying out these works, and the exactions of the local officials gave little encouragement to the Arab cultivators to extend their holdings. Since the war, under British administration, large areas have already been brought into cultivation by the extension of irrigation canals, and under a just rule cultivators are now able to enjoy the fruits of their labour. Communications by road and river have been improved, and Basra, transformed into an up-to-date port, promises in the near future to be an important centre of the cereal trade ; its position in regard to India is of some importance, as the surplus crops of Mesopotamia will be a safeguard for India when the monsoon rains fail in that country.

British East Africa.—During recent years the cultivation of wheat has been taken up by farmers with considerable success. The Nasin Gishu Plateau, covering an an extensive area at an altitude of from 6,000 to 7,000 feet, is an excellent wheat country as regards both yield and quality ; the country is flat and free from timber, and offers every facility for growing wheat on a large scale. Proximity to the railway is one of the important factors in growing wheat for export, but with improved communications there should be an outlet for the surplus produce of the country. Rust has proved troublesome, but as the result of experiments, rust-resisting varieties of seed are being found, and it should be possible for this country to produce wheat on a large scale.

Northern Africa.—More than four-fifths of the total area cultivated in Egypt is capable of growing wheat, but so long as cotton remains the highly remunerative

crop it is, there is very little chance of extending wheat cultivation. During 1915 and 1916, owing to restrictions in the cultivation of cotton, the wheat area was extended and there was a surplus of grain for export. Under normal conditions, however, Egypt does not grow enough cereals for her own requirements.

Algeria and Tunis produce at present about 1,200,000 tons of wheat, of which Algeria exports about 150,000 tons. Hard durum wheats are largely grown by the natives, and the yield per acre is very low. The French colonists in Algeria, who cultivate the ordinary French varieties of wheat, obtain very good returns.

Wheat and barley are extensively grown in Morocco, and before the war the wheat exports averaged about 30,000 tons. With the improvement in the position of the natives under a better government, more land will come under cultivation, and by the provision of roads and railways opening up new districts, and reducing the cost of transport to the ports, there should be a great advance in the export trade. There are numerous flour mills in Morocco, and also factories for making Italian pastes, for which the hard Moorish wheat is very suitable.

Russia.—Before the war wheat cultivation in Russia was making great progress, especially in Little Russia, and the regions of the Middle and Lower Volga, where the finest qualities of wheat are grown. In the Caucasus, Turkestan and Western Siberia the wheat areas were also being extended. Wheat exports had been advancing, and for the five pre-war years amounted on an average to nearly 4,500,000 tons a year. The quantity exported varied greatly from year to year: in 1908 it was as low as 1,500,000 tons, and in 1910 it was over 6,000,000 tons. Siberia has hitherto been little developed as a wheat-growing country; in Eastern Siberia rye is grown, and forms the chief food of the people. This country, with the neighbouring Chinese Province of Manchuria, contains vast tracts of land suitable for wheat. Owing to the upheaval in Russia and the utter disorganisation of all means of transport, it cannot be expected that exports of cereals on a large scale will be renewed, even for some time after peace has been restored.

United States.—At the present time the United States is the greatest wheat-producing country in the world. The estimated production of wheat in 1919 is 1,300,000,000 bushels, or about 34,800,000 tons, which represents more than one-fourth of the world's production of this cereal. The following statement shows the great advance made in the cultivation since the outbreak of the war.

Period.	Average area.	Average production.	Average yield per acre.
	Acres.	*Bushels.*	*Bushels.*
1891–1900 . .	43,100,000	559,000,000	13·0
1900–09 . .	46,678,000	659,509,000	14·0
1909–13 . .	47,068,000	685,259,000	14·5
1914–17 . .	53,038,000	799,320,000	15·0
1918 . . .	58,852,000	917,000,000	15·5
Estimated 1919 .		1,300,000,000	

The Government encouraged farmers to grow wheat by various concessions and by fixing the price of wheat in advance of sowing; for the 1919 crops the farmer was guaranteed $2·20 per bushel, which compares favourably with the average farm price of 87 cents per bushel obtained between 1909 and 1913. Prior to the outbreak of war exports had been declining: the average exports for the five pre-war years were 2,900,000 tons, whereas between 1900 and 1902 they had averaged 5,790,000 tons. This decline was caused partly by the small annual increase in production, and also by the rapid increase in population, and by a considerable increase in per capita consumption. With increased production, and economy in consumption during the war, exports have rapidly advanced and averaged 5,576,000 tons between 1914–17. The exportable surplus for 1919 is estimated at from 350,000,000 to 400,000,000 bushels, or rather less than one-third of the estimated production. Various kinds of wheat are grown in the United States. The hard spring wheat, comprising about one-third of the total production, is grown principally in Minnesota and the two Dakotas, and is of fine quality, similar to the wheat produced in the Middle Volga region of Russia. About two-thirds of the wheat is winter sown, and a very large proportion of this is raised in the Central Western States, of which Kansas is the most important. The wheats grown in the Pacific and Western Intermontane districts are generally soft and starchy. Much unimproved

land suitable for wheat still remains, and the yield per acre, which is low, can be improved. The flour manufacture of the United States is of great magnitude, and the flour export trade much the largest in the world. Between 1903–7 the exports of flour averaged 1,335,000 tons; before the war the average had fallen to about 1,000,000 tons, but during the war the average was nearly 1,500,000 tons. The United Kingdom is one of the principal customers for flour; South American countries also draw their supplies largely from this source. During the war France and Italy had to indent extensively on the United States.

Argentina.—Although at so early a date as 1585 wheat grown in La Plata was milled at the city of Cordoba, it was not until 1890 that Argentina ceased to import both wheat and flour. In recent years the production of wheat has increased to a remarkable extent, as the following statement will show.

Period.	Area under wheat.	Production.	Exports.
	Acres.	*Tons.*	*Tons.*
1890–91 . .	1,981,000	790,000	370,000
1899–1900 . .	8,027,000	2,587,000	1,804,000
1907–08 . .	14,227,000	4,900,000	3,400,000
1909–13 . .	15,785,000	4,282,000	2,586,000
1914–17 . .	17,864,000	5,900,000	

The principal type of wheat cultivated is the semi-hard red grain of Italian origin, which does not degenerate; soft French and Russian varieties, and also hard durum wheats for the local manufacture of macaroni are also grown. In the colder southern regions a fine quality of hard winter wheat is now being cultivated. The principal wheat areas are in the provinces of Buenos Ayres, Cordoba, and Santa Fé, but it is probable that the wheat belt will tend gradually more south, and that La Pampa will eventually become the chief source of supply. The breaking up of large estates has enabled the people to buy small farms, and has encouraged settlement on the land. The average yield of wheat per acre is small, as the crops are liable to damage from locusts and drought. With improved cultivation and abatement of the locust plague Argentina should be able to raise much larger crops. There are numerous flour mills in the country, and exports of flour

have averaged about 120,000 tons, the bulk of which goes to Brazil.

Brazil.—Wheat was formerly grown in the three most southern States, but the cultivation was abandoned because of the prevalence of rust. The advance in the material condition of the people of the country has resulted in a demand for wheaten bread in place of bread made from mandioca flour, and to meet this demand, flour and wheat have been largely imported from Argentina. For some years past the Government have given every assistance and encouragement to farmers to grow wheat, and good progress has been made in the southern States, where there are extensive areas of land suitable for wheat and also well provided with transport facilities. There appears to be every prospect that Brazil will be able to supply her own requirements in course of time, and also have an exportable surplus.

THE DEVELOPMENT OF COTTON GROWING IN NYASALAND

Although the production of cotton for export has only been undertaken in Nyasaland during the last sixteen years, the crop has long been grown by the natives for local use. When Dr. Livingstone visited the Shiré Valley in 1859, he found that cotton was being cultivated in almost every village. He reported that there were three varieties of cotton in the country, of which two were exotic and one indigenous. The former were grown as perennials but were replanted every three years, and these varieties were largely grown in the Upper and Lower Shiré Valleys on small areas not usually exceeding half an acre. The cotton was of good quality, and was regarded in Manchester as nearly equal to the best New Orleans. The indigenous variety was grown in the Highlands and planted afresh every season; the fibre was shorter than that of the foreign cotton, but was preferred by the natives as it furnished stronger cloth. Dr. Livingstone added that he rarely entered a village without finding the people engaged in preparing the cotton and spinning and weaving it.

The cotton was removed from the seed, either with the fingers or by means of an iron roller working on a smooth wooden block, and the spinning and weaving were effected by primitive spindles and looms, all the processes being painfully slow.

It was not until the year 1903 that cotton was cultivated by Europeans in Nyasaland, and in 1905 a cotton expert (Mr. S. Simpson) was appointed with a view to the production of the fibre on a commercial scale for export. At that time, the dependence of the United Kingdom on the United States for the raw material required for the manufacturing industry of Lancashire, and the inflation of cotton prices owing to speculation, were being widely discussed, and the British Cotton Growing Association had just been created with the object of promoting cotton cultivation in new districts, and particularly within the British Empire. The question of cotton growing was then taken in hand by the Department of Agriculture in Nyasaland, and a native industry was organised and fostered. European planters in the Protectorate had just suffered heavy losses by the failure of the coffee crop, and were therefore easily persuaded to turn their attention to cotton. Much assistance was rendered to the planters by the British Cotton Growing Association in financing the crop, through their local agents the African Lakes Corporation, and arranging for its sale in Manchester.

In the early stage of the industry, *i.e.* prior to 1909, when the Department of Agriculture was established, no control was exercised by the Government over the importation of cotton seed into the country, and numerous varieties, including Egyptian, Sea Island, American Upland, Brazilian, Indian and other kinds, were introduced, and were sown with little or no discrimination. The cultivation of the different varieties in proximity to one another led to hybridisation of the plants and mixing of the seed at the ginneries, and it followed that in a few years the cotton produced showed great irregularity in length, strength and colour, and its value was considerably lessened. Subsequently large quantities of seed were destroyed and all the varieties were discarded with the exception of Egyptian kinds, which were restricted to the

river levels, and a long-stapled American variety from Mississippi, which was confined to the Highlands, and in its present form is widely known as Nyasaland Upland.

No history of cotton growing in Nyasaland would be complete without recording that the seed from which Nyasaland Upland evolved was originally imported from America by the Zambesi Industrial Mission and first successfully cultivated on a commercial scale by the late Mr. Livingstone at Magomero for the A. L. Bruce Trust.

Cotton growing can be practised in all districts of Nyasaland which have an altitude of less than 3,000 feet above sea level, but higher elevations are too cold for the crop. Prior to 1914, Egyptian varieties were grown in areas with an elevation of less than 2,000 feet and Nyasaland Upland on the higher lands; now all Egyptian varieties have been discarded in favour of Nyasaland Upland, which is more reliable under Central African conditions even at the lowest elevations. Nyasaland Upland has been carefully acclimatised and improved by continued single-plant selections by the Agricultural Department, and seed of this variety produced at the Government Cotton Farms has been distributed widely to growers in Nyasaland, Portuguese East Africa, Rhodesia and Transvaal, with very satisfactory results, and the cotton lint is highly esteemed in Lancashire and realises good prices.

The steady progress of the Nyasaland cotton industry is shown by the following figures, giving the quantities and values of the exports from 1902 to 1916:

Year.	Quantity. lb.	Value. £	Year.	Quantity. lb.	Value. £
1902	692	—	1910	1,736,999	58,687
1903	56,897	1,778	1911	1,359,904	44,199
1904	285,185	5,941	1912	3,237,555	80,939
1905	776,640	16,180	1913	2,401,142	65,486
1906	526,119	15,345	1914	2,648,508	72,068
1907	403,486	13,998	1915	3,065,248	68,586
1908	756,120	28,355	1916	3,462,478	127,131
1909	858,926	26,209			

In 1917 the exports declined, owing largely to the disorganisation of transport, and therefore failed to indicate the position of the industry. The area under

cultivation in that year, however, amounted, in spite of the difficulties occasioned by the war, to 28,372 acres as compared with 29,580 acres in 1916. It is estimated that the area now devoted to cotton by European planters in the Protectorate amounts to 27,342 acres.

The present position of the Nyasaland cotton growing industry and the possibilities of its extension have been dealt with recently in a Report prepared by Mr. J. Stewart J. McCall, Director of Agriculture, Nyasaland, for the information of the Empire Cotton Growing Committee. The following notes are compiled from this Report.

The total area of Nyasaland is 25,161,924 acres, and it is estimated that 1,309,000 acres possess climatic and soil conditions suitable for cotton cultivation. According to the variation in the climatic conditions of different parts of the country, the cotton-growing lands may be conveniently divided into three areas, (1) the Shiré Valley, (2) the Shiré Highlands, and (3) the Lake Nyasa region.

Shiré Valley Cotton Area

This area consists of a strip of land along the course of the Shiré River, extending northwards for 240 miles from Marka to Fort Johnston and of a width varying from five to twenty-five miles. It has an elevation ranging from 200 to 1,500 ft., and an annual rainfall of 25–30 in. There are at least 140,000 natives in this area, and the services of some thousands of natives from the adjacent Portuguese territory are available during the planting season. The land now under cultivation and the possibilities of extension are estimated as follows :

Cotton Areas in the Shiré Valley

	Estimated area at present under cultivation.	Estimated possible extension of area.
	Acres.	*Acres.*
Ndindi Marsh	1,500	35,000
Elephant Marsh	700	10,000
Chiromo	4,000	10,000
Chikwawa	4,300	60,000
Lisungwe and Matope	1,050	3,000
Liwonde-Basale and Balakas	1,500	15,000
Lake Pamalombe to Fort Johnston	400	85,000
TOTAL	13,450	218,000

Of the total area of 13,450 acres now devoted to cotton in the Shiré Valley, about 10,000 acres are under European control. In the Chikwawa area of West Shiré District, four British planters are cultivating 4,000 acres annually with the aid of native labour, largely recruited from Portuguese territory. Under the supervision of these planters, the crop, amounting to about 1,300 bales of 400 lb. each, is ginned, baled and transported by river. This is a case in which the cultivation could only have been undertaken by Europeans, as the land is too remote from the water supply to be worked by the natives. In one instance, to overcome difficulty of transport and water, an old tramway line has been laid down to connect the plantations with the ginnery near the Shiré River, and land six miles inland is now being planted with excellent results. There are at least 60,000 acres of similar Crown lands awaiting development.

During the last few years, small cotton holdings (of about 100 acres) have been leased by banyans or small Indian store-keepers, especially in the Ruo District, and several Indians, formerly employed on the Shiré Highlands Railway, are undertaking cotton growing. The educated natives are also interesting themselves in the industry, and there are 10,000 acres of Crown lands on the Elephant Marsh, Ruo District, on which small plantations could be established. The extension of this system of small holdings is hampered by the fact that the natives usually have no capital, and it is therefore suggested that the Government should make advances to selected natives at a low rate of interest, and supervise their efforts until they are in a position to maintain their plantations without further assistance.

The best cotton-growing land in the Shiré Valley is situated in the Ndindi Marsh, south of Port Herald, which is flooded in January and February by the overflow of the Shiré River. The soil is fertile and maintains its humidity to such an extent that cotton planted at the end of February or the beginning of March will give a full yield with only 2 or 3 in. of rain. This land offers excellent opportunities for immediate development. Selected acclimatised seed is now available for sowing; cattle

thrive well and can be used for cultivation; there is a good supply of labour for harvesting, and the seed-cotton can be conveyed by the railway to the ginnery at Port Herald. A Government Cotton Farm has been established at Nyachiperi, near the Marsh, and has given results which indicate that the 'Ndindi Marsh, if properly cultivated on a commercial scale, could be made to yield up to 7,000 bales of cotton per annum. The average yield obtained from an experimental planting on 90 acres amounted to more than 2 cwts. per acre, this yield being nearly twice as heavy as the average yield obtained in the Highlands.

Between Chikwawa and Liwonde, there are two small areas suitable for cotton growing, situated on the Lisungwe near Matope, and it is estimated that these, if fully developed, would give an annual crop of 500–1,000 bales. Large expanses of good cotton soil occur on both banks of the Shiré River between Liwonde and Fort Johnston. There are also about 85,000 acres of rich, dark alluvial soil in the neighbourhood of Lake Pamalombe which will be available for cotton cultivation on the completion of the railway from Luchenza to Lake Nyasa.

Shiré Highlands Cotton Area

In the Shiré Highlands, cotton can only be grown successfully on the lower and more sheltered lands, the best areas being the Ruo and Luchenza Valleys, the Mlanje Plain, and the Ntondwe and Chikala sections of the Zomba District. These areas have an annual rainfall of 35–45 in., a maximum shade temperature of about 95° F., and are generally suitable for European settlement.

Cotton Areas in the Shiré Highlands

	Estimated area at present under cultivation. *Acres.*	Estimated possible extension of area. *Acres.*
Ruo and Luchenza Valleys	11,000	11,000
Mlanje Plain	3,600	170,000
Zomba and Ntondwe	4,300	10,000
Chikala	100	100,000
Total	19,000	291,000

Although the best cotton soils are to be found in the northern half of the Highlands, the European plantations

are at present situated in the southern half, as the existing Shiré Highlands Railway affords the necessary transport facilities. In this region 17,600 acres are now planted with cotton by Europeans. It is not anticipated that much extension will take place in the Ruo and Luchenza Valleys, as tobacco gives better returns than cotton and is a less speculative crop. No further development can be expected in other parts of the Highlands until the railway has been extended northwards from Luchenza to Fort Johnston, but when this is accomplished, 170,000 acres of good cotton land in the Mlanje Plain will be available for cultivation.

The natives in the Shiré Highlands number about 293,000, and as they tend to settle in the neighbourhood of the European plantations, the provision of their food supply is a matter of some difficulty. This fact gives additional importance to the question of extending the railway as soon as possible.

Little development has taken place hitherto in the Chikala section of the Highlands, but, if water holes and wells were provided, 100,000–200,000 acres could be rendered suitable for cotton growing and the settlement of the natives.

Experimental Work.—In 1909 the Department of Agriculture commenced a series of selection experiments in the Highlands with a locally grown form of American Upland cotton, and the selections were subjected to careful laboratory examination. In 1910 a small area at Nkanda, seven miles south of Zomba, was devoted to the cultivation of the first year's selections. As sufficient land was not available at Nkanda for the extended trial of the further selections, an area of 1,000 acres was opened up at Namiwawa, about eight miles south-east of Zomba, and this has now become the general Experimental Farm for all crops grown in the Shiré Highlands. Samples of the selected Upland cottons and other varieties were submitted to the Imperial Institute for examination, and these have been described in this BULLETIN (1912, **10,** 527). As a result of the reports received on the selected American Upland cottons, two selections, viz. "Nyasaland Upland, No. 57" and "Nyasaland Upland, No. 13," were retained

for extended cultivation. The former is the better cotton for cultivation on most soils, but the latter is more suitable for certain soils of the lower levels.

The Nyasaland Upland cottons, Nos. 57 and 13, have also been grown continuously at the Lower River farm in the Shiré Valley, and give a larger yield per acre in this locality than when grown in the Highlands. The stocks of seed from both Government Farms are distributed to the growers. Samples of the cotton from the ordinary crop of No. 57 have been repeatedly valued at prices ranging from 1½*d.* to 3*d.* per lb. in advance of "middling" American, and during 1917 cotton derived from this seed realised the high price of 22·50*d.* per lb., and in 1918 twelve bales of selected Nyasaland Upland No. 57 was sold for 28*d.* per lb.

Lake Nyasa Cotton Area

Lake Nyasa has an elevation of 1,645 ft. above sea-level, and possesses large areas on its southern and western shores which are admirably adapted for cotton cultivation. The Lake is suitable for shipping, and serves as the cheapest means of transport for three-fifths of the Protectorate, as well as for a large part of Northern Rhodesia. In order to attract European planters and to enable a native cotton industry to be organised, it is essential that there should be a sufficient service of steamers to carry crops grown on a commercial scale, and that the railway should be extended to the Lake. Hitherto the only attempts to grow cotton in this area have consisted in a series of experiments on the different classes of soils, but these have proved that the cultivation could be carried on with success.

The following are estimates of the land now under cotton cultivation and the possibilities of extension.

Cotton Areas in the neighbourhood of Lake Nyasa.

	Estimated area at present under cultivation. *Acres.*	Estimated possible extension of area. *Acres.*
Sangazi-Livilezi	400	260,000
Lintipe-Dwangwa	nil	500,000
North Nyasa	nil	40,000
Total	400	800,000

In the South Nyasa and Dedza Districts, in the south-west arm of the Lake between the Sangazi and Livilezi Rivers, there is a large area on which it has been found possible to produce 120–150 lb. of lint per acre. Similar land occurs between the Lintipe and Dwangwa Rivers of the Dowa and Marimba Districts respectively. In the North Nyasa District there are about 40,000 acres on which cotton of exceptional quality can be grown. The West Nyasa District is of little importance for cotton cultivation, but is well adapted for the production of tea and rubber.

The cotton areas of Lake Nyasa have a native population of at least 130,000, whilst in the higher plateau country within 20–40 miles of the Lake, there are about 500,000 natives from whom labour can be drawn for work on European estates, etc. The natives of the plateau region are not able to find employment near their villages, and many of them seek work in the Shiré Highlands or in Rhodesia, sometimes travelling as much as 300 miles on foot. The establishment of a cotton-growing industry would therefore be of great benefit to them and discourage their leaving the Protectorate.

Possible Extension of the Industry

From the foregoing account of the Nyasaland cotton-growing industry, it will be seen that whereas at present there are only about 32,850 acres devoted to the crop, there are no less than 1,309,000 acres of suitable land awaiting development. It is estimated that the present output (nearly 3,500,000 lb. in 1916) may be increased in the near future to ten times this amount, and that ultimately a crop of 1,024 million lb. might be produced. This extension of the industry, however, depends on the native labour available and the provision of improved internal communications and cheap and rapid transport to the coast.

The native population would be inadequate for the full expansion of the industry if the cultivation is conducted by the ordinary native methods, but it is considered that this difficulty could be surmounted by the use of agricultural machinery and animal or mechanical traction.

With regard to transport facilities, it is suggested that at the present time the demands of the industry could be met by the extension of the railway to Lake Nyasa and the coast at Bura, the construction of a few good roads, and the provision of two cargo steamers on the Lake.

The development of cotton cultivation could also be benefited by the enlargement of the Agricultural Department, the establishment of a further experiment station and seed farm, the erection of three additional ginneries, and the provision of improved agricultural implements for the use of the growers.

In concluding this article it would be advisable to point out that, while emphasising the importance of the cotton industry, it should be remembered that in point of export and capital involved the tobacco industry is even of greater importance, and that many of the recommendations set forth in favour of improved transport facilities apply equally to that industry. In its comparative infancy the industry produced 4,700,000 lb. of cured tobacco, which at present commands a ready sale in the London market at approximately 2*s.* per lb., and is the most important source within the Empire of the Virginian type of tobacco.

THE WORK OF THE RAW MATERIALS COMMITTEE OF THE IMPERIAL INSTITUTE[1]

The Federation of British Industries has recently appointed a representative (Mr. Alexander Johnston, of the North British Rubber Company) on the Raw Materials Committee of the Imperial Institute, and it is proposed to give a short account of this Committee, with illustrations of its work, for the information of the members of the Federation.

The Committee, of which Sir Algernon Firth, Bart., is Chairman, is nominated by the Association of Chambers of Commerce, and includes representatives of the following Chambers: London, Liverpool, Manchester, Glasgow, Bristol, Hull, Norwich, and Middlesbrough. The principal

[1] Reprinted from *The Bulletin of the Federation of British Industries* for June 2, 1919.

objects of the Committee are (1) to consider the results of the investigations of important raw materials, chiefly new or little known, at the Imperial Institute, and to take steps where desirable to bring the information to the notice of British merchants and manufacturers through the medium of the Chambers of Commerce; and (2) to suggest sources of supply of raw materials required by British manufacturers.

The objects and organisation of the Imperial Institute may be briefly stated as follows:

The principal object of the Imperial Institute is to promote Inter-Imperial Trade and Industry, especially in raw materials, by technical research, commercial investigation, and communication with merchants and manufacturers, with a view to the export of materials from the country of origin or to the establishment of industries there for their utilisation. An important branch of the work of the Institute relates to the raw materials of British countries overseas, which are received for investigation.

Under the Imperial Institute (Management) Act of 1916, an Executive Council has been appointed, including representatives of the Dominions. Lord Islington, formerly Governor of New Zealand, and subsequently Under Secretary of State for the Colonies, and Under Secretary of State for India, is Chairman of the Executive Council. A separate Advisory Committee has been appointed for each Dominion, with the High Commissioner in London as Chairman. There is also an Advisory Committee for India and various Technical Committees, including Technical and Commercial Experts, such as those on Timbers, Silk, Minerals, etc., in addition to the Raw Materials Committee.

The Imperial Institute includes extensive laboratories and workshops with a large staff for investigation and research into the composition and uses of raw materials of all kinds. There is also a Technical Information Bureau with a special staff to deal with enquiries received, and the collection and arrangement of information relating to the raw materials of the Empire in all their aspects.

The Exhibition Galleries of the Institute contain representative collections of the raw materials and other

exhibits of the Dominions, India and the Colonies. In addition, special reference collections of raw materials are maintained.

The *Bulletin of the Imperial Institute*, which contains records of investigations, special articles, etc., is published quarterly by Mr. John Murray, London, price 11*s*. a year, post free. There are also numerous special publications issued by the Institute relating chiefly to the production and utilisation of raw materials.

The operations of the Imperial Institute in finding commercial outlets for raw materials may be illustrated by the following summary of certain investigations relating to the utilisation of raw materials which have been considered by the Raw Materials Committee.

Sant Grains from the Sudan.—This material is prepared from the pods of *Acacia arabica*, which are known as "sant" pods in the Sudan. Large supplies are available and an export trade is desired. The material was therefore investigated at the Imperial Institute.

The whole pods contain about 30 per cent. of tannin, but by grinding the pods to a granular powder, and then removing the seeds and fibrous matter by sifting, a product is obtained in which the proportion of tannin is considerably increased. Two samples of "sant grains" thus prepared were examined at the Imperial Institute, and found to contain 55 and 60 per cent. of tannin respectively, which is equal to the amount present in many tanning extracts. The material therefore appeared likely to be a valuable tanning agent, and at the request of the Imperial Institute a consignment was recently forwarded from the Sudan for further examination and sale.

The technical trials carried out with this consignment gave satisfactory results, and the material was disposed of at the price of £45 per ton ex store London. The tanners who purchased the material employed it in place of sumach for finishing skins tanned with bark, and they reported that the results appeared to be quite satisfactory. When larger supplies of the sant grains are available, they propose to tan a quantity of skins entirely with the material.

It is thought that there will be a very large demand for sant grains equal to this trial consignment, and a

further shipment of 50 to 100 tons has been requested as soon as possible.

It is stated that 2,000 tons of the sant grains can be produced annually in the Sudan.

Spent Wattle Bark.—Wattle bark is extensively used in South Africa and in the United Kingdom in the tan-yards, and for the preparation of tanning extract, and recently tanners in the United Kingdom have been employing considerable quantities of the bark. Large supplies of the spent bark are therefore available in both countries, and the Imperial Institute investigated the possibility of finding a use for the waste material. The results showed that the spent bark can be successfully employed for the manufacture of brown paper and cardboard, and that it may be possible to utilise it for the cheaper grades of cream or white paper. The attention of paper-makers was drawn to the material by the Imperial Institute, and arrangements were made to use it in paper mills in this country. A similar use is to be made of the spent bark in South Africa.

The spent bark has been tried at a number of paper mills, but a practical difficulty has arisen in connection with its utilisation, owing to the fact that the paper produced is liable to contain objectionable dark specks. These specks are due to the presence of a corky layer on the bark which is not readily attacked by the usual treatment employed in the production of paper pulp. A further investigation has accordingly been carried out at the Imperial Institute with a view to obviating this defect, and a process has been worked out which enables the specks to be removed, and a superior class of paper to be prepared.

Dura from the Sudan.—Some time ago an investigation was carried out by the Imperial Institute in conjunction with feeding trials, in order to determine the value of dura grain (Sorghum) from the Sudan as a feeding stuff for animals. The results of the trials were exceedingly satisfactory. It was found that the dura closely resembles maize in chemical composition, and that it is about equal in value to the latter grain as a feeding stuff for cattle and poultry. Preliminary experiments were afterwards

made with the grain as a brewing material, and recently large-scale trials have been carried out in order to obtain definite information as to whether dura could be successfully used in the brewing industry. The dura was tried (1) for malting; (2) as roasted grain for colouring and flavouring purposes; (3) for flaking; and (4) for the production of glucose. The results were very promising, especially with regard to the production of glucose, and a large consignment of dura has been requested from the Sudan in order that manufacturing trials may be made on a large scale.

Drying Oils.—It having been suggested to the Raw Materials Committee that increased supplies of Tung oil (Chinese wood oil) would be welcomed by paint and varnish makers in this country, as the supply from China was insufficient, the Imperial Institute undertook to enquire as to the possibility of cultivating the trees yielding this oil in British possessions. As a result of communications with the botanical and agricultural authorities in India and Ceylon cultivation experiments with the trees have now been arranged in these countries, the seed for the purpose having been procured by the Imperial Institute from China.

Similar action has been taken with respect to Perilla oil, which also belongs to the class of drying oils employed in the manufacture of paints and varnishes. Enquiries made by the Imperial Institute among manufacturers in this country indicated that it would be useful if increased supplies of this oil could be procured from British sources. At the present time the oil is chiefly prepared in Japan from seed grown in Manchuria, China and Japan. The Imperial Institute obtained a supply of seed from Japan, and has distributed a quantity to each of the following countries for trial: India, East Africa Protectorate, South Africa, Rhodesia and Cyprus. It is hoped that it may be possible to undertake the cultivation of the seed on a commercial scale in one or more of these countries.

A new drying oil, derived from Po-Yoak nuts from Sierra Leone, has been investigated recently by the Imperial Institute. These nuts contain a drying oil which resembles Tung oil in properties, and could probably be utilised

like the latter in paint and varnish making, linoleum manufacture, etc. Large-scale technical trials will be necessary in order to establish the value of the Po-Yoak oil, and the Imperial Institute is making enquiries as to the quantity of the nuts available in Sierra Leone.

Waxes.—There has been a very large demand recently in this country for hard vegetable waxes which can be used for the same purposes as Carnauba wax. In addition to other technical uses, these waxes are utilised in conjunction with paraffin wax for the manufacture of the cardboard containers employed for packing jam, fruit, etc., in place of tins.

Attention was accordingly drawn by the Imperial Institute to the following waxes which had been examined at the Imperial Institute, and appeared likely to be of value for the purposes indicated.

Sugar-cane Wax from Natal.—The refuse press-cake obtained in the preparation of sugar from sugar cane contains about 10 per cent. of a hard wax, and proposals have been made to extract this wax on a commercial scale. Some time ago the Imperial Institute examined a sample of sugar-cane waste, and determined the yield and nature of the wax and its possible uses. Attention was then called to the possibility of preparing the wax commercially, and recently a Company has been formed in Natal to extract the wax from the refuse obtained at several large sugar estates. Consignments have already been forwarded to London for disposal, and it is anticipated that considerable supplies of the wax will be available from Natal in future.

Waxes from Colombia.—A species of Ceroxylon wax from Colombia has been examined at the Imperial Institute and found to be suitable for use as a substitute for Carnauba wax. Samples of this wax were distributed by the Imperial Institute to a number of firms in this country with the result that much interest has been taken in the product, and offers to purchase trial consignments have been obtained. Arrangements are now being made in Colombia for the collection and shipment of the wax, and it is hoped that consignments will be available shortly.

Another wax from Colombia, derived from a species of myrtle, has also been examined at the Imperial Institute.

This wax is not so hard as the Ceroxylon wax, and would not serve as a complete substitute for Carnauba wax, although it could be utilised for important technical purposes. In this case also arrangements are being made to obtain commercial supplies from Colombia.

Atropine.—Egyptian henbane was first investigated at the Imperial Institute in 1899, and shown to be one of the best sources of the alkaloid atropine, which is largely used in medicine. The value of the Egyptian plant was brought to the notice of British firms by the Imperial Institute at that time, but the manufacture of atropine was then principally carried on in Germany, and the bulk of the Egyptian henbane was accordingly exported to that country. The stoppage of the German supplies of atropine on the outbreak of the war and the large demands for this drug by the army caused an extreme shortage in this country, and the attention of British manufacturing chemists was again drawn by the Imperial Institute to the possibilities of utilising the Egyptian henbane as a source of atropine. As a result of this action the manufacture of atropine was taken up by several firms in this country and during 1917 these firms purchased about 100 tons of Egyptian henbane for their requirements.

Indian Opium.—An exhaustive investigation of Indian opium has been in progress at the Imperial Institute for some years, and the results obtained have conclusively proved that this opium contains on the average a much larger percentage of morphine and codeine than is usually supposed, and would be suitable for European use. Out of a series of 102 specimens from all the principal opium districts of India only thirty were found to be unsuitable for medicinal use in the United Kingdom owing to a deficiency of morphine. A more recent investigation of samples of opium from the United Provinces gave similar results.

The opium formerly used in this country was principally obtained from Turkey and Persia, and the outbreak of the war seriously interfered with supplies. The Imperial Institute had for some time been urging the use of Indian opium in this country for medicinal and manufacturing purposes, and in view of the shortage of supplies during

the war the Government of India gave permission for the export of shipments of opium to the United Kingdom. Indian opium is now being freely utilised by the British makers of morphine and codeine.

Ores for the Manufacture of "Special" Steels.—Prior to the war British steel-makers had relied largely on Germany, France and the United States for supplies of the alloys of titanium, tantalum, tungsten, molybdenum, etc., which are added to steel in the manufacture of the very hard and tough steels now used for making "high speed" and other special steels which are of first-rate importance in modern engineering industries. Nearly all the ores from which these alloys are made are more or less monopolies of the British Empire so far as production is concerned, though before the war the output went chiefly to foreign countries, where the alloys were made and exported to this country. This condition of things has been remedied since the war, and the alloys are now being made here. The Institute had prepared, and in some cases published complete records of the occurrence of these ores within the Empire, had made analyses of many of them, and had in fact taken action with the Admiralty to get Western Australian tantalite used in this country for steel manufacture before the war.

Early in 1915 there was a great shortage of molybdenite in this country, and the Institute took action to increase supplies. A memorandum was prepared stating the quality of ore required in this country, the possible sources of supply within the Empire, the value of the ore, and the chief uses to which it was applied. Copies of this memorandum were sent to all the Mines Departments in those parts of the Empire where molybdenum ores were known to the Institute to be obtainable. A large increase in supplies to this country resulted. This action was specially effective in Canada, and in a paper recently published in *National Progress* (Toronto), Mr. C. C. Mackenzie gives an account of the recent important developments of molybdenite production in that Dominion, directly resulting from action taken by the Canadian Mines Department in response to the circular issued by the Imperial Institute.

The Imperial Institute has also been instrumental in

placing alloy makers in this country in touch with producers of titanium ores in Australia and India, and of tungsten ores in India and South Africa. It has also prepared a map of the mineral resources of the Empire in which particular attention is given to the sources of ores used for special steel alloys.

Monazite.—Until a few years ago the sole source of supply of thoria, the principal and essential ingredient in the mantles used for incandescent gas lighting, was monazite from Brazil. The Brazilian deposits were under the control of the German Thorium Syndicate, which was thus in a position to dictate to the rest of the world the price at which mantles should be sold and where they should be made. Many attempts were made to break this monopoly, and the Imperial Institute has invariably given assistance to British firms who desired to secure independent sources of supply. The discovery of the new mineral thorianite in Ceylon, which proved to be the richest ore of thorium, was made by the Mineral Survey, carried on in co-operation with the Imperial Institute. It provided a new, though small, independent supply, and also gave a great stimulus to the search for thorium minerals. In recent years monazite has been found by the Imperial Institute in sands from Ceylon, Malay Peninsula, Nyasaland, Northern Nigeria, and elsewhere in the Empire. The Imperial Institute also made the first analysis published of the monazite from Travancore, which is now the most important source of supply of this mineral in the world.

The continued investigations of the Mineral Survey in Ceylon have resulted in the discovery of beach deposits of monazite sand in that island, and the Government of Ceylon have now made arrangements for working them. The Ceylon sand has been investigated by the Imperial Institute, which has also conducted trials of concentrating machinery, and finally selected plant which has been erected in Ceylon for working the sands. The deposits are less extensive than those of Travancore, but they will make an effective contribution to British sources of supply of this important mineral.

Indian Hides.—The Institute has considered the ques-

tion of finding a market within the Empire for the large quantities of raw Indian cowhides (kips) which before the war were chiefly exported to Germany and Austria, and a special Committee was appointed to deal with this question. Suggestions have been made as to the measures necessary to ensure the tanning of Indian kips on a large scale in this country after the war. In addition enquiries have been instituted in South Africa, Canada and Australia.

A trial consignment of the kips was forwarded by arrangement direct from Calcutta to South Africa, and was disposed of by the Mines and Industries Department to various tanners in the Union for trial. Reports from some of the tanners have now been received, and are exceedingly favourable, one of the firms stating that in their opinion " the supply from India of hides of this class will be the salvation of the upper leather manufacturers in South Africa." The tanners are taking steps to obtain regular consignments of the kips as soon as freight can be obtained from India, and it would appear that a good market will be available for the hides in South Africa.

As regards Canada there has been sent to the Ministry of Trade and Commerce at Ottawa a representative collection of Indian kips which is being exhibited to tanners at centres throughout the Dominion. A few sample bales of the kips have also been forwarded to interested firms. The opinions received from Canadian tanners indicate that there will be a considerable market for Indian kips in the Dominion as soon as ordinary trade conditions are restored.

Enquiries have also been made in Australia, and at the request of the Federated Master Tanners' and Leather Manufacturers' Association of Australia a statement was furnished giving full particulars of the various grades of Indian kips. It is stated that there may be an important opening for the hides in Australia.

It is obvious from the few illustrations now given that the operations of the Imperial Institute have an important bearing on the objects for which the Federation of British Industries was founded, and that co-operation between the two bodies is likely to achieve valuable results.

NOTES

Manganese Ores.—The second of a series of monographs on the chief mineral resources of the British Empire, prepared under the direction of the Mineral Resources Committee of the Imperial Institute, is now published by Mr. John Murray. It deals with manganese ores, and has been compiled by A. H. Curtis, B.A.(Lond.), M.I.M.M., Assoc.M.I.C.E., F.G.S., who was specially attached during the war to the staff of the Imperial Institute.

The monograph gives an account of the world's production of manganese ores, with special reference to the resources within the Empire, and indicates possible sources of supply for the future. The Russian output of ore has considerably decreased owing to the war, and India now takes first place in the world's production, Brazil, which has largely increased her output in recent years, coming next in order of importance. The demand for manganese in the iron and steel industry is continually increasing, more particularly for the manufacture of ferro-manganese, and the question of adequate supplies of ore is therefore of importance.

The subject is dealt with in three chapters. The first describes the ores of manganese, and gives a brief survey of their occurrence, character and uses. The second chapter deals fully with the sources of supply within the Empire, and the third describes shortly the deposits in foreign countries. The monograph concludes with a bibliography of the principal publications on the subject of manganese.

Rubber Research in Ceylon.—Since 1913 an extensive series of investigations has been conducted under the Ceylon Rubber Research Scheme, with a view to ascertaining the best methods of preparing plantation rubber of the quality required by manufacturers. Investigations have been carried on at the Experiment Station of the Department of Agriculture, and on private estates in Ceylon, under the supervision of an Executive Committee consisting of representatives of the planting industry and of the Department of Agriculture, and a Technical Committee comprising planters and the scientific officers of the Department, whilst the Imperial Institute has investigated the vulcanising and mechanical properties of the rubber, with the assistance of an Advisory Committee, consisting of manufacturers and others connected with

the rubber industry in the United Kingdom. At the commencement a definite scheme of work was drawn up by the Imperial Institute, with a view to determining the effect of various methods of preparing and treating rubber on its vulcanising and mechanical properties. Further investigations into the effect of tapping on the trees and into the physiology of the rubber tree were outlined in Ceylon, and have been systematically conducted.

The results so far available have been published recently in a volume entitled *Rubber Research in Ceylon* (Colombo: Government Printer, 1918). It includes the following papers by L. E. Campbell, B.Sc., F.I.C., Rubber Research Chemist in Ceylon, issued previously as separate *Bulletins:* "Seasonal Variations in the Storage of Plant Food and their Relation to Resting Periods," "The Effect of Tapping on the Movement of Plant Food," "Physiological Effects of Various Tapping Systems," "On the Variation in the number of Latex Vessels at different Heights from the Ground" (written in conjunction with G. Bryce, B.Sc., Assistant Botanist and Mycologist, Department of Agriculture), "Measurements of 'Bark Renewal,'" "On the Natural Clotting of Rubber Latex," and "Variability in Rubber Manufacture." The first eight interim reports made by the Imperial Institute on the tests of the vulcanising and mechanical properties of the rubber prepared in Ceylon are also printed (cf. this BULLETIN, 1916, **14**, 495, and 1918, **16**, 409), together with a summary of the general conclusions of these experiments.

The volume, which comprises 236 pages and twelve folding diagrams, is obtainable from the Imperial Institute, price 7*s*. 6*d*. net.

Openings for Indian Lac-Ware Toys in the English Market.—At the request of the Secretary of State for India, the Committee for India of the Imperial Institute has conducted an enquiry into the possibilities of increasing and developing Indian trade in raw materials, more particularly with the United Kingdom and the other countries of the Empire. The Committee formed a number of Special Committees to deal with the various materials concerned. The Special Committee on Gums and Resins has conducted an enquiry with a view to developing the trade in Indian lac, and has made a full report to the Secretary of State for India in which the whole subject is discussed and recommendations made. This report will shortly be published.

One method of extending the lac trade of India is to

increase the small export trade in Indian lac-ware toys to the United Kingdom. At the request of the Special Committee the Imperial Institute undertook to ascertain whether such toys were likely to be favourably received in this country and the steps required to promote the trade.

The representatives of two large retail firms, after inspecting the small collection of lac-ware toys and fancy articles on exhibition in the Indian Section of the Imperial Institute, expressed the opinion that a market could be found for certain of the articles, and suggested consulting importers of similar articles which are made in Russia and Japan. Two firms of importers were approached, one of which is chiefly concerned with Japanese goods, whilst the other is interested chiefly in goods of Russian origin. Both these firms stated that a market could be found for Indian goods of turned lac-ware, provided that they could be exported in large quantities at a reasonable rate properly packed from India. Both firms pointed out that difficulties existed which prevented trade on a large scale in these goods, as no organisation existed in India to supervise the execution of orders, the selection of the goods for United Kingdom requirements, and the packing on economical lines ; or to make advancements to the Indian workers. They were, however, willing to trade these toys provided that firms of Indian merchants could be persuaded to import them.

In view of the possibility of an opening for Indian toys on the London market, the Imperial Institute suggested that a comprehensive priced collection of Indian toys should be sent from India to the British Industries Fair last year, the collection to be afterwards transferred to the Indian Section of the Imperial Institute for reference purposes. It was not found possible to give effect to the proposal to exhibit at the British Industries Fair, but detailed information was communicated by the Imperial Institute to the Director of Commercial Intelligence, Calcutta, and was circulated to departments and firms concerned with native arts and crafts, intimating that a collection of toys should be sent to the Imperial Institute.

As a result, collections of lac-ware toys and fancy articles have been received at the Imperial Institute from Village Industries, Ltd., Cawnpore ; the Victoria Technical Institute, Madras ; and from Rewah. The collections have been examined by importers, and the suggestions made by them for improving or altering the designs in order to meet the requirements of the United Kingdom market have been transmitted to India. A further consignment of selected toys made on the lines suggested have been

received from Village Industries, and have been approved by importers. The articles included in these collections comprise various small wooden toys, skittle pins and balls, bats and balls, croquet sticks and balls, rattles, tops, wrestlers' clubs, wooden animals, figures representing occupations, etc.

One of the two firms of importers referred to above has now purchased the collection of Cawnpore toys, and has also sent a trial order.

Another firm of importers has been put into communication with exporters of toys in India and has stated that it was prepared to place trial orders for Indian toys from Rewah and Cawnpore.

The collection of Indian toys was inspected at the Imperial Institute by Her Majesty the Queen, and a number of specimens selected by Her Majesty were at her request forwarded to Buckingham Palace.

The initial stage in this trade has now been passed, and it remains for exporters in India to comply strictly with the instructions given by importers on this side as to designs, packing and despatch of consignments, in order to build up a large and prosperous trade such as, before the war, existed in these goods between Russia and the United Kingdom. The elimination of Russian goods for the time being from the United Kingdom market should facilitate the entry of Indian goods, but more attention must be paid to "finish" if Indian goods are ultimately to compete successfully with the turned lac-ware toys made in Russia.

The Formation of Acetic Acid in Heart-damaged Jute.—In the last number of this BULLETIN (1919, **17**, 130) reference was made to investigations conducted in India by R. S. Finlow, Fibre Expert to the Government of Bengal, on the damage caused to jute by baling it in a moist condition. These enquiries showed that fermentation is set up in the wet jute by the action of bacteria which attack the cellulose of the fibre and apparently effect its hydrolysis. As far back as 1908 samples of heart-damaged jute were examined at the Imperial Institute, and in the course of the investigation it was ascertained that the material contained free acetic acid. Experiments showed that when normal jute is hydrolysed by boiling with dilute caustic soda solution, acetic acid is likewise formed (see also Cross, Bevan and Isaacs, *Journ. Soc. Chem. Indust.*, 1892, **11**, 967). There seems no doubt that the acetic acid present in the heart-damaged jute examined at the Imperial Institute was a product of bacterial fermentation, as Omelianski (*Centrbl. Bakt.*, II,

1902, **8**, 193) showed that this acid amongst others is produced when cellulose is broken down by the action of certain bacteria.

RECENT PROGRESS IN AGRICULTURE AND THE DEVELOPMENT OF NATURAL RESOURCES

In this section of the Bulletin *a summary is given of the contents of the more important papers and reports received during the preceding quarter, in so far as these relate to tropical agriculture and the utilisation of the natural resources of the Colonies, India and the Tropics generally. It must be understood that the Imperial Institute accepts no responsibility for the opinions expressed in the papers and reports summarised.*

AGRICULTURE

Foodstuffs and Fodders

Burma Beans.—Some years ago the attention of the agricultural authorities in Burma was directed by the Imperial Institute to the unsatisfactory character of certain cargoes of Burma beans imported into the United Kingdom, and it was suggested that the Agricultural Department might encourage the cultivation of varieties of beans which yield less prussic acid than those in question. This matter was considered at a Departmental Conference in 1912, and it was decided that (1) attempts should be made to grow Madagascar beans in Burma and that the resulting crops should be tested at the Imperial Institute, and (2) a collection should be made of samples of all the varieties of beans grown in the Province for submission to the Imperial Institute. Reports on the beans examined at the Imperial Institute have been published from time to time in this Bulletin (1914, **12**, 355; 1915, **13**, 196; 1916, **14**, 150; 1918, **16**, 275).

Trials with the Madagascar bean at experiment stations in Burma have shown that the strains so far examined are not agriculturally suitable to replace the local Pe-gya and Pe-byu-gale beans, the yield per acre being low. The Madagascar beans showed an increase in yield of prussic acid in two years from 0·0025 to 0·008 per cent., but in the following year the percentage fell to 0·004. As is stated in this Bulletin (1918, **16**, 279), the beans produced during the next two years yielded on the average almost the same amounts of prussic acid as the original seed beans, viz. 0·002 to 0·0025 per cent., and in some cases the yield was actually lower. The differences in the yield of

prussic acid have been attributed to variations in the climatic conditions, but no definite relation has yet been traced between these conditions and the formation of prussic acid.

More encouraging results have been secured by a search for non-poisonous forms among the ordinary Burma crop of Pe-gya beans, and an account of this work has been given by F. J. Warth, M.Sc., and Ko Ko Gyi, and issued as *Bulletin No.* 79, 1918, *Agricultural Research Institute, Pusa.* About 100 single-plant samples were collected from the typical Pe-gya areas of the Sagaing District and grown separately. The beans from a number of these plants were examined, and the prussic acid was found to vary from 0·0004 to 0·03 per cent. From these cultures, the two best, the two worst, and four intermediate specimens were selected for further work, and these were grown at three different stations, viz. Mandalay (in the dry zone), Hmawbi (in the wet delta zone), and Tatkon (in middle Burma, where the rainfall is intermediate in character). The results showed that the seed giving the least prussic acid produced beans which also furnished the lowest quantity, and similarly the seed giving the highest amount of prussic acid produced beans giving the highest amount, and, in general, the cultures maintained the property of producing the same relative quantities of the poison under varying conditions of soil and climate. It is therefore concluded that the formation of prussic acid is an inherited character of pure, single-plant cultures. Although the relative prussic acid content is constant, the actual amount of prussic acid varies considerably with the soil and climatic conditions. Differences in the colour of the beans from a single culture do not indicate differences in the power of producing prussic acid in their offspring. The best cultures always yield some prussic acid, but the quantity in the best cultures is only half as great as that yielded by the Madagascar beans forwarded to Burma as safe for consumption.

Jowar.—It has been shown by work conducted at the Imperial Institute (this BULLETIN, 1906, **4**, 333) that *Andropogon Sorghum*, which is known in India as "jowar," contains, at certain stages of its growth, a cyanogenetic glucoside, termed "dhurrin." This glucoside is hydrolysed by an enzyme contained in the tissues of the plant with formation of prussic acid, which has frequently caused the poisoning of cattle. A study of the conditions which favour the accumulation of dhurrin in the jowar plants has been carried out at the suggestion of the Agricultural

Chemist to the Government of Bihar and Orissa, and an account of the results has been given by Manmathanath Ghosh, M.A., Assistant Professor of Chemistry and Physics, Sabour Agricultural College, in the *Agric. Journ. India* (1919, **14**, 107). The chief aim of the experiments was to ascertain the effect of different times of planting, and also of water-logging of the soil, on the formation of the glucoside. It has been found that the presence of large quantities of moisture in the soil is associated with low production of dhurrin, and that water-logging is distinctly unfavourable to its formation. Contrary to the usual belief, healthy and vigorous plants yield more prussic acid than weak and stunted ones. The time of planting does not seem to have any effect on dhurrin formation, but a crop planted late has a better chance of producing smaller quantities of the glucoside owing to the abundant moisture usually present in the soil at such a time. It thus appears that the weather is the principal factor on which the development of the poisonous properties of the plant depends. Dhurrin occurs principally in the leaves and young shoots, and this suggests that, since these parts of the plant assimilate the greatest amount of nitrogenous material, the production of the glucoside is correlated with nitrogenous metabolism, and supports the theory that prussic acid is an intermediate product in protein formation, and that its occurrence is an evidence of nitrogen assimilation. The soil is only of minor importance in the production of dhurrin and is only effective in so far as it can supply nitrogenous matter to the plant. It has been pointed out by earlier workers that nitrates exert a direct influence in the production of prussic acid. On the other hand, certain American results indicate that in a rich soil, the addition of nitrogenous manures produces no appreciable effect, whilst in a poor soil there may be an increase, though only to a slight extent. It is evident, therefore, that the soil is only a minor factor in the production of the glucoside, and that the climatic conditions, particularly the rainfall, exert a far greater influence.

Oils and Oilseeds

Coconuts.—The cultivation of coconuts in Trinidad is said to be the most profitable branch of agriculture, and is likely to increase in importance in the future (*Board of Trade Journ.*, 1919, **102**, 252). In 1917 nearly 17,000,000 locally grown nuts were exported, chiefly to the United States, and over 7,000,000 lb. of copra, while about 140,000 gallons of oil were produced for local consumption.

Altogether there are about 27,000 acres under coconuts in the island. The tree occurs almost all round the coast, the chief producing districts being the Cedros district with over 9,000 acres, of which 7,000 acres are bearing nuts, and the Mayaro district with 7,500 acres in bearing. The Cedros district produces about 21,000,000 nuts a year, chiefly on large estates, whilst about 12,000,000 nuts are produced annually in the Mayaro district. The conditions in the latter region are less favourable and the nuts smaller than in the Cedros district. There are three oil factories in the Mayaro district, producing annually about 100,000 gallons of oil and 500,000 lb. of oil cake, the latter being mostly sold as a feeding-stuff for live-stock. Coir fibre is also produced in Trinidad, though large quantities of husk are still wasted.

Great confidence in the future of coconut planting appears to exist in Trinidad, and coconut planting is being carried on by sugar and cocoa planters.

Small extensions in coconut planting were made in St. Vincent in 1917–18 (*Rep. Agric. Dept., St. Vincent*, 1917–18, p. 23). Large areas are commencing to bear fruit, and the manufacture of copra and oil will require attention. Up to the present nuts and copra have been exported, but owing to local transport difficulties, and the desirability of retaining the residual meal in the island for food for stock and as manure, the erection of oil mills is considered desirable.

In the Gold Coast about one-third of the native coconut palms planted at Assuantsi in 1910–11 bore fruit, 2,562 nuts being obtained in 1917, compared with 106 in 1916, whilst over one-quarter of the Ceylon variety planted in 1912–13 bore fruit in 1917 (*Rep. Agric. Dept., Gold Coast*, 1917, p. 7). A germination test on 500 fruits showed that when whole fruits were sown 36 per cent. germinated, whilst in the case of those fruits from the base of which a slice of husk had been removed a germination of 58 per cent. was shown.

Linseed.—Owing to the increased demand due to the war the area under linseed in Argentina was increased by 185,000 acres in 1918 (*U.S. Daily Commerce Rep., No.* 28, Feb. 3, 1919, p. 527). The principal Provinces in Argentina which produce linseed are: Santa Fé with over 1,250,000 acres, Cordoba with about 750,000 acres, and smaller areas in Buenos Aires and Entre Rios. The total area in 1918–9 was over 3,300,000 acres, the production of seed being estimated in January 1919 at 705,000 metric

tons. Owing to the cessation of hostilities the future prospects of the market for linseed are somewhat uncertain.

Most of the linseed is exported, the United States being the largest buyer in 1918; there are a few oil mills in Argentina, but owing to the difficulty of obtaining machinery, the lack of containers for the oil and the absence of local demand for oil cake, the manufacture of linseed oil in Argentina does not appear to be of great importance, though the production of oil rose from 2,353 metric tons in 1914 to about 5,000 metric tons in 1917, in which year 1,525 metric tons of oil were exported.

Oil Palm.—Oil palms of different varieties planted in the Gold Coast bore fruit in 1917, but it was not possible to determine with certainty whether the fruit is true to type, as the palms are too young to produce properly developed fruits (*Rep. Agric. Dept., Gold Coast*, 1917, p. 8). It appears that trueness to type cannot be decided until another generation of palms produced by self-pollination of the palms already planted has fruited. At Peki, cultivation has resulted in an increase in productiveness, and in size and weight of the fruit bunches.

In Southern Nigeria seeds of known varieties were planted out in 1911, and some commenced to bear fruit in 1916. In the palms raised from fruits with thin shells all the fruits examined contained nuts with typical thick shells (*Rep. Agric. Dept., Southern Provinces, Nigeria*, 1917, p. 8).

According to Bories there are in the Ivory Coast three installations of machinery for the manufacture of palm oil (*Bulletin des Matières grasses, No.* 2, 1919, *Institut Colonial, Marseilles*, p. 41). The "Usine d'Impérie" employs the plant made by Haake of Berlin (see this BULLETIN, 1917, **15**, 58, 70), which is capable of working 10–15 tons of fruit in twenty-four hours, and is run by a native of the Gold Coast under the occasional supervision of a mechanic of the company. At the "Usine d'Ana à la Société Pericarp" the Trevor process is employed. In this process the fruits are first steamed in barrels and then depulped. The latter is effected by a special machine in which the fruits are subjected to the action of circular saws, and of wire brushes attached to a rapidly moving endless belt (see *Bulletin des Matières grasses*, No. 6, 1918). This installation can treat 25 tons of fruit in twenty-four hours. Poisson's machinery (this BULLETIN, 1917, **15**, 67, 74) is employed at the "Usine Blachon," and this

machinery is also installed at the works of the "Syndicat für Oelpalmen Kultur" at Maka in the Cameroons, where it has been found possible to produce oil containing as little as 1 to 1·5 per cent. of free acid and therefore suitable for sale in Europe for edible use.

The author considers it desirable to await the results of at least one year's work with the different installations before expressing an opinion on their relative efficiency, but he remarks that the Haake process appears to be rather slow in operation, and to necessitate the use of large volumes of water, while the depulper of the Trevor machinery is somewhat delicate, and needs careful supervision, though this installation is rapid in action, capable of producing oil of low acidity, and is also said to give the highest yield of oil.

Owing to the difficulty of obtaining spare parts from Europe the Trevor plant has apparently not been working to its full extent. There has been a lack of sufficient supplies of palm fruit, and consequently all these plants have only been worked irregularly. This difficulty is caused by the fact that the palms do not bear fruit all the year round, the chief crop being obtained in the Ivory Coast from March to June, and a second and less important crop in November and December. The present high prices of oil have tended to render this lack of supply a matter of less importance than it would be under normal conditions with palm oil at a comparatively low price.

The same author describes the methods employed by natives for the preparation of palm oil in the Dabon region of the Ivory Coast. In this region nearly 3,000 metric tons of palm oil and over 2,500 metric tons of kernels were produced in 1917, the oil being of good quality. The native process, with slight modifications, has been tried in Gaboon, and found to yield oil with from 2·5 to 9·5 per cent. of free acid when care is taken to prevent excessive fermentation of the fruits. The process is carried out in the following manner: The fruit heads are collected by the natives working in gangs of eight (four men and four women), each gang gathering about 2,500 lb. of heads, equivalent to about 1,600 lb. of fruit, per day. Removal of fruits from the heads is facilitated by keeping the heads for three or four days, and no fermentation is said to take place in fruits left on the heads. After removal from the heads the fruits are laid aside to be worked up the following day, when they are placed in three large iron pots each holding about 22 gallons or about 190 lb. of fruit. About 3½ to 4½ gallons of water is added to each pot, which is covered over with banana leaves, the fruits being then

boiled for about an hour and a half. The softened fruits are pounded in a mortar until the pulp separates from the nuts, when the latter are picked out by women. The pulp is then placed in wooden tubs and re-heated by means of very hot stones which are vigorously stirred up in the pulp. The heated pulp is then placed in a rough sack made of canes, and having a strong bar passing through the bottom end, and firmly fixed above the ground; another bar passes through the top of the sack, and on twisting this the oil is pressed out from the heated pulp, and falls into a tub below. The oil is finally purified by boiling and skimming. Working in this way eight natives can produce about 22 gallons of oil in a day, the yield of oil being about 12 per cent. of the weight of fruit. Small screw or hydraulic presses would probably increase the efficiency of the process.

Plantations of oil palms at Gazi in the Belgian Congo contain five varieties of palms bearing several forms of fruit similar in character to the varieties existing in other parts of West Africa (*Bulletin Agric. Congo Belge*, 1918, **9**, 218). The thick-shelled variety with a thin pericarp is known as "Olombi" or "Difumbi" and is the most common variety here, as in other parts of West Africa. The other varieties include "Mohei," with a thick pericarp and nuts having thin shells, of which only one tree is known on the Gazi plantations, and also the variety having nuts without hard shell.

Miscellaneous.—Seeds of *Camellia drupifera*, Lour., from Tonkin have been found to contain nearly 24 per cent. of oil, equivalent to about 48 per cent. in the kernels (*Bulletin Econ. Indo-Chine*, 1918, **21**, 232). The oil may retain traces of saponin, but is suitable for edible purposes after this has been removed.

The tree known as "Cay-Sen," whose seeds are used in Tonkin as a source of oil, has been identified as *Bassia Pasquieri*, M. Dub.; H. Lee emend. (*Bulletin Econ. Indo-Chine*, 1918, **21**, 735).

The seed and oil of Egyptian lettuce (*Lactuca scariola* var. *oleifera*) have been examined by Griffiths Jones (*Rep. and Notes, Public Health Laboratories, Cairo*, No. 1917, p. 45), with results similar to those obtained for Sudan lettuce seed and oil examined at the Imperial Institute (this BULLETIN, 1919, **17**, 37).

Rubber

Hevea

Gold Coast.—Experiments carried out since 1910 in the Gold Coast have shown that the half-herring-bone system of tapping yielded nearly 4½ lb. more rubber per tree than the large **V** system over the period 1910–17 (*Rep. Agric. Dept., Gold Coast,* 1917, p. 6). At all stations where tapping has been carried out, striped canker has occurred, and has resulted in the diminution or complete loss of latex; the disease is under investigation. Trees at the Assuantsi agricultural station continue to make good progress (*loc. cit.*, p. 46) and root disease has been less troublesome than in former years, though several cases of attack by *Hymenochaete* and *Fomes* have had to be treated, and have in some cases proved fatal.

Belgian Congo.—Hevea trees planted at Yangambi (between Stanleyville and Basoko) in the Belgian Congo on clayey-sand soil in 1911 and 1913 have grown well (*Bulletin Agric., Congo Belge,* 1918, **9**, 78). There are altogether about 440 acres planted with nearly 38,200 trees. In November 1917, about three-quarters of the area was in a neglected condition, but the whole area has now been cleared, and broken and defective trees have been removed and replaced by stumps. In spite of neglect in the past, which has caused uneven development of the trees, it seems certain that soil and climate are suitable, as trees which have been properly cared for have developed well and are comparable with trees of similar age on good plantations in Malaya.

In 1918 2,430 trees were tapped on the quarter single cut system for the smaller trees, and with two cuts for those over about 28 in. in circumference 3 ft. from the ground. The tapping was carried out by twelve natives. About 10,000 trees, which were ready for tapping, could not be tapped owing to lack of skilled tappers and material for the coagulation and preparation of the rubber. From the results of two months' tapping it is estimated that from 356 to 396 lb. of rubber per acre should be obtainable by tapping on 300 days in a year.

The native labourers when trained become efficient tappers, and are considered to be equal in skill to tappers on rubber estates in the East, but there appears to be some difficulty in obtaining sufficient regular labourers at present to enable the plantations to be worked to the best advantage.

Germination of Seed.—The rapid loss of germinative power of Hevea seed has caused much trouble in the

establishment of plantations of Hevea and frequently valuable consignments of seed have entirely failed to germinate when planted after transport. An elaborate investigation of the germination of Hevea seed and of the factors influencing it has been made by Maas (*Archief voor Rubbercultuur*, 1918, **2**, 666). It is considered essential that the seeds should not be allowed to dry ; whilst only fresh seeds, recognisable by their lustre and the fact that the kernels are not loose in the husk, should be gathered for sowing. The seeds should be planted out in beds composed of loose sandy soil, in a position sheltered from the sun, and the beds should be carefully watered during the first few days.

In planting in seedbeds the seed should not be wholly covered, but should lie either on the side or with the flat, striped side downwards. Transference to open nurseries is best made when the young stem bends up, the young plant being planted in the ground so that the seed is covered. Some planters transfer the seedlings as soon as the main root appears, and before the auxiliary roots have sprouted, but the author finds that about 20 per cent. of seedlings are lost in this way, while only about 1 per cent. are lost by the first method.

It is regarded as unsafe to pack seed for transport in airtight boxes unless the temperature is below 10° C. Dipping seeds in paraffin-wax appears to be effective, but is laborious. It seems probable that shipment in cold storage of seeds packed in boxes without packing materials will prove valuable, at any rate for limited quantities. Probably the most convenient method of transporting the seeds is to pack them in strong wooden boxes lined with oiled paper, Japanese or packing paper ; the packing boxes should not exceed 12 × 16 × 20 in. or the seeds in the middle may ferment. As a packing material some substance which will retain moisture, such as powdered coconut refuse mixed with soil or crushed charcoal, should be used ; the charcoal must be moistened, while a little damp clay is also useful.

Diseases.—In an address on rubber diseases Petch calls attention (*Trop. Agriculturist*, 1919, **52**, 34) to the occurrence on many estates in Ceylon of "top-canker." This disease occurs on the upper branches, the bark of which splits longitudinally in lines a foot or more in length, and also transversely, so that a length of the stem is covered with loose rectangular scales. The bark may die down to the wood, forming a large open wound, and finally an irregularly gnarled and thickened area. The cause of the

disease is uncertain; wounds on the larger stems should be scraped and tarred, whilst younger stems which are attacked should be removed and burned.

Bobilioff asserts that brown-bast disease is due to physiological causes, and that it is not caused by living organisms (*Archief voor Rubbercultuur*, 1919, **3**, 172). Areas of bark were isolated by cutting away the surrounding bark so that the flow of latex to the isolated areas was prevented. The isolated areas were then tapped, and after six weeks all developed brown-bast disease.

The "black thread" disease is stated to be present to some extent on most of the plantations in Burma (*Rep., Agric. Research Inst., Pusa*, 1917–18, p. 77). It attacks leaves and causes defoliation, and is not confined to the fruits and tapping surfaces as was supposed to be the case previously.

The attacked trees do not recover readily from the effects of leaf-fall, and the yield of latex is reduced during October to December, when, under normal conditions, the trees should be giving a maximum yield. The removal of seeds and admission of light and air by thinning and pruning are effective in reducing "leaf-fall" and "black-thread" on the tapping surface, but systematic removal of seed is so expensive that it is doubtful whether it can be carried out on a commercial scale. Application of disinfectants to the tapping cut has been found to prevent and check "black-thread" in the Federated Malay States, but was ineffective on a plantation in Burma, apparently owing to the disinfectant being washed away by the heavy rains. The rainfall in different districts does not appear to have any direct connection with the extent of the disease on the tapping cut or on the damage due to the disease. The disease is very prevalent and causes severe damage to the bark where the tapping cuts are deep; where the cuts are light the disease is less prevalent and severe.

An interesting paper on the effect of wounds on Hevea trees and the methods of treatment is contributed by Keuchenius to the *Archief voor Rubbercultuur* (1918, **2**, 639).

Structure of Laticiferous Tissue.—In contradiction of the results of previous investigators Arisz finds that the various concentric layers of latex vessels in the stem of *Hevea* trees are connected with one another (*Mededeelingen Besoekisch Proefstation*, No. 11, 1919, p. 139). It follows therefore that laticiferous vessels not actually opened by the tapping cut may have some influence on the yield of latex. Latex from a tapping cut at the base of the stem may have been derived from the stem, main

root or lateral branches possessing several latex vessels connected with undegenerated latex layers at the base of the stem, or from lateral roots.

General

The question of the inferiority of rubbers from French West African colonies and the possibility of improving their quality is receiving considerable attention (*Bulletin des Caoutchoucs, No.* 2, 1919, *Institut Colonial, Marseille*). The inferiority of these rubbers is largely due to the presence of impurities introduced by imperfect methods of collection and preparation, and it is considered that the quality of such rubbers would be considerably improved by the establishment of factories in Africa or in Europe for washing and drying the rubber before it is shipped or placed on the market.

Fibres

Jute.—The *Board of Trade Journal* (1919, **102**, 614) contains an article by H. M. Acting Commercial Secretary at Rio de Janeiro on the prospects of jute cultivation in Brazil. The high cost of jute imported from India has led to a discussion as to the possibility of the production of jute in Brazil. In view of the importance of this question, the Brazilian Minister of Agriculture sent two emissaries to India to study the jute-growing industry, and to report as to the feasibility of jute cultivation in Brazil. One of these emissaries reached the conclusion that jute could not be grown profitably in Brazil since the climatic conditions are unfavourable, and the industry would require the employment of a large number of highly skilled and practised labourers to cut the stems and separate the fibre by hand. He also pointed out that India has an excellent system of communications, which is an important factor in jute cultivation and is entirely lacking in Brazil. The other emissary extended his tour to Cuba and, as a result of his experience in that island, was led to express much more hopeful views. He reported that the labour problem could be solved by the use of machinery, such as is employed in Cuba, and that the opinion that jute can only be grown on low-lying alluvial lands is erroneous, as he saw excellent jute plantations in Cuba on land which had previously been devoted to the cultivation of sugar-cane.

Cotton

Union of South Africa.—References to the progress of cotton growing in South Africa have been made in the

South African Journal of Industries (1918, **1**, No. 13, 1183; No. 15, 1383; No. 16, 1532). It is stated that 12,000 acres are now devoted to cotton in the Transvaal and 1,000 acres in Zululand. The industry is also extending in certain districts of Natal where the plant can be grown under ideal conditions. Successful experiments have been made at Amatikulu, and about two miles to the south of this place a ginnery has been established, which contains an 80-saw gin with an output of 1500–1600 lb. of lint per day of eight hours. This enterprise has been carried out by the Zululand Cotton Company, Limited, who contemplate the installation of special hydraulic presses. Cotton cultivation is now being taken up by the natives in some parts of Zululand, and particularly good results have been obtained at Indulinde, in the Eshowe Division, where a cotton of excellent colour, good strength, and a length of 1¼ in. has been produced; this cotton was regarded as worth 3*d.*–3½*d.* per lb. in advance of the price of "middling" American. Many farmers in the Waterberg District are turning their attention to cotton growing, and success has already been achieved in the Tzaneen District of the Transvaal. About 90 acres have been planted at Malelane, and a ginning plant has been installed. Excellent cotton has been produced at Rustenburg; the 1918 crop was at one time expected to amount to 800,000 lb., but adverse weather conditions and the attack of insect pests caused so much damage that the estimated yield was subsequently reduced to 400,000 lb. It is not improbable that the prevalence of insect pests was due to the objectionable practice of ratooning the cotton instead of destroying the plants at the end of each season.

India.—In the *Agric. Journ. India* (1919, **14**, 165) an account is given by G. L. Kottur, Cotton Supervisor, Southern Division, Bombay Presidency, of an improved type of cotton, which has been developed for cultivation in the Southern Maratha country. The black cotton soil tract of this region includes over a million acres in the districts of Dharwar, Belgaum, and Bijapur of the Bombay Presidency, and similar physical features are common to the adjoining cotton-growing areas in the native States of Kolhapur, Miraj, Sangli, Hyderabad and Mysore. On the whole of this tract a variety of *Gossypium herbaceum* is grown, which is known locally as "jowari-hatti" and produces the Kumpta cotton of commerce. The seed is sown in August–September, and the cotton is ready for the first picking by February–March. The crop, on the average, amounts to 320 lb. of seed-cotton per acre, yielding

only 80 lb. of lint, of fairly long but weak and irregular staple. The cotton plants are of two distinct types: (1) an erect type characterised by meagre development of limbs and vegetative branches, and (2) a bushy type with 5–10 limbs. The first type is tall and produces a prominent fruiting branch from each node, whilst in the second type it is the vegetative branches which are prominent and vigorous, the fruiting branches on the main stem being suppressed and insignificant. The importance of this difference lies in the fact that the bolls are produced, first on the fruiting branches of the main stem, next on the limbs, and lastly on the vegetative branches. In February and March there is a marked tendency for the late flowers to fall off, and in order to secure a good yield it is therefore necessary to select the early flowering plants, *i.e.* those of the erect type. By continued field tests and unit selection with this erect type, a plant has now been obtained which produces 12 per cent. more seed-cotton than the local kind; this seed-cotton yields 12 per cent. more lint on ginning than the local seed-cotton, and the lint is valued at 5 per cent. in advance of the local Kumpta cotton. The new cotton has been submitted to practical spinning tests, and has been very favourably reported on by the spinners. It is proposed to produce seed of this type in large quantities for distribution to the growers.

West Indies.—The following figures showing the production of Sea Island cotton in the various islands of the West Indies during the year October 1, 1917, to September 30, 1918, and the exports during the same twelve months have been published in the *Agricultural News* (1918, **17**, 390; 1919, **18**, 39).

Production of Sea Island Cotton

Colony.	Quantity.	Estimated value, calculated at 3s. per lb.
	lb.	£
Grenada	1,334	200
St. Vincent	329,115	49,367
Barbados [1]	192,981	28,947
Montserrat	409,885	61,483
Antigua	59,950	8,993
St. Kitts	215,223	32,284
Nevis	258,286	38,743
Anguilla	46,654	6,998
British Virgin Islands	16,231	2,435
Trinidad [1]	450	68
TOTAL	1,530,109	229,518

[1] *Figures taken from the export returns.*

In addition to this Sea Island cotton, 241,524 lb. of

Marie Galante cotton, of estimated value £23,811, was produced in Grenada, and 38,285 lb., of estimated value £5,105, in St. Vincent; there was also a production of 2,335 lb. of native cotton produced in the British Virgin Islands.

Exports of Sea Island Cotton

Colony.	Quantity.	Estimated Value.
	lb.	£
Grenada	1,551	204
St. Vincent	384,025	62,980
Barbados	192,981	28,370
Montserrat	265,104	44,335
Antigua	53,000	9,938
St. Kitts	2,457	368
Nevis	187,748	28,162
Anguilla	652	98
Virgin Islands	20,905	2,031
Trinidad	450	75
TOTAL	1,108,873	176,561

Besides this Sea Island cotton there were exports of Marie Galante seed-cotton from Grenada and St. Vincent, amounting to 496,020 lb. of estimated value £31,035, and 82,409 lb. of estimated value £6,319, respectively; there were also shipped from the Virgin Islands 953 lb. of native cotton of value £32 and 1,785 lb. of native seed-cotton of value £89.

It will be observed from these figures that the quantities of cotton exported from the West Indies during the year were considerably less than the total amount produced. This was due to difficulties of transport, much cotton still awaiting export at the end of September.

In the *West Indian Bulletin* (1918, **17,** 79) some interesting observations are recorded by R. E. Kelsick, Acting Chemical Assistant, St. Kitts, on the relation between the length of the cotton fibre and the rainfall. The results indicate that in St. Kitts the length which Sea Island cotton will attain in any season depends on the amount of water supplied to the plant during the critical period of boll development and particularly between the 15th and 21st day after the opening of the flower.

In a report on the cotton industry of St. Vincent (*Rep. Agric. Dept., St. Vincent,* for the year ending March 31, 1918) it is stated that the area devoted to Sea Island cotton in that year was 3,458 acres as compared with 2,404 acres in the preceding year. About 60 per cent. of this area was planted by estate owners, and 40 per cent. by small growers. The season was favourable, the rainfall being well distributed, and the total crop amounted to

329,115 lb. or about 95 lb. per acre. The work undertaken to control the cotton stainer (*Dysdercus delauneyi*, Leth.) was continued (compare this BULLETIN, 1918, **16**, 115), and it is considered that the adoption of the measures proposed for this purpose benefited the growers to the extent of several thousand pounds sterling. In order to prevent the introduction of the Mexican boll weevil and the pink boll worm as well as of certain pests and diseases occurring in other parts of the West Indies, the importation of cotton seed and seed-cotton has been prohibited from all sources. This regulation will not inflict any hardship on the growers, as the local types of Sea Island cotton have a good reputation and the Department of Agriculture are in a position to maintain a full supply of seed and to assist in the improvement of the different types grown.

In the Southern Grenadines the area planted with Marie Galante cotton in 1917–18 was 1,253 acres, and the crop amounted to 38,285 lb. of lint. The small yield per acre is explained by the fact that other crops, such as maize, peas and cassava, are grown among the cotton. The cotton realised excellent prices, the later shipments being sold at 2*s*. 8*d*. per lb.

In the *Annual Report for* 1916 *on the Turks and Caicos Islands* [Cd. 8434–14] it was stated that there are thousands of acres of land in these islands which are suitable for cotton growing, and that it was hoped that the development of a cotton industry among the peasants would improve their impecunious condition. Three bales of cotton were shipped during that year, and the staple was described in Liverpool as of excellent quality. In the *Annual Report for* 1917 [Cd. 8973–18] it is reported that the cultivation in the Caicos Islands is steadily increasing among the peasant landholders, and that the crop for that year amounted to eight bales, which realised 1*s*. 8*d*. per lb. or a total of £237. After deducting all expenses, including transport charges, there remained £165 for distribution to the growers. The industry is now regarded as being permanently established in the islands.

Corea.—According to the *Board of Trade Journal* (1919, **102**, 452) the area devoted to cotton growing in Corea in 1918 was nearly 220,000 acres, and the crop amounted to slightly over 100,000,000 lb. It is hoped that Corea will eventually become the main source of Japan's supply of cotton and render the Japanese spinning and weaving industries independent of foreign supplies. It is considered that the Provinces of North and South Zenra, North and South Keisho and North and South

Chusei are suitable for American cotton, and the Provinces of Keikido, Kokaido and North and South Heian-do for the native variety. Still further expansion is contemplated, and a scheme has been arranged according to which, by the end of 1928, there will be 250,000 acres planted with American cotton and 85,000 acres with the native kind. It is hoped that the area under cultivation will ultimately reach 625,000 acres with an annual production of 333,000,000 lb. of cotton.

NOTICES OF RECENT LITERATURE

STEWART'S HAND BOOK OF THE PACIFIC ISLANDS. A reliable Guide to all inhabited Islands of the Pacific Ocean, for Traders, Tourists and Settlers. Compiled by Percy S. Allen. Pp. 286, Demy 8vo. (Sydney, N.S.W. : McCarron, Stewart & Co., Ltd., 1918.)

The scope of this work is clearly indicated in the title. It deals not only with all the larger and better known islands and groups of islands of the Pacific, such as New Guinea, Samoa, Fiji, New Caledonia, Hawaii, Solomon Islands, etc., but also with such little known places as Malden Island, where the only inhabitants are the employees of an Australian firm working the guano deposits, and the outlying dependencies of New Zealand and Australia. Particulars are given of the geography and history of the various islands, their products, and in most cases their climate.

Lists of business houses, trade statistics and tariffs are included in the case of the more important places.

THE GRASSES AND GRASSLANDS OF SOUTH AFRICA. By J. W. Bews, M.A., D.Sc. Pp. vi + 161, Med. 8vo. (Pietermaritzburg : P. Davis & Sons, Ltd., 1918.) Price 9*s.* net ; post free, United Kingdom and abroad 9*s.* 6*d.*

The present book is a further contribution to the study of South African plant ecology, a subject to which Professor Bews has paid much attention. The author explains that it was originally intended to publish a separate paper dealing with the plant succession in the grasslands of South Africa, but as the work progressed its scope widened, important economic questions became involved, and it was decided to publish it in book form rather than in one of the scientific journals. The book is divided into five sections. The first includes a general description of grasses, an explanation of Clement's system of ecological nomenclature, which is adopted by Professor

Bews, and a glossary of technical terms. The second section, which occupies forty pages, consists of a key to the genera and species of South African grasses. This is one of the most notable features of the book, and should prove of great value to students as providing a simple means of identifying the 500 or so different species. In the third section ecological notes are given on the principal species in each genus, the study of leaf anatomy receiving special attention. Professor Bews considers that from the point of view of the value of a grass as fodder, a study of simple transverse sections of the leaves is probably even more useful than elaborate chemical analyses of the herbage, as the latter will vary according to the time of year and even according to the state of the weather. The value of a grass for pasturage depends to a great extent on the amount of hard, thick-walled tissue in the leaf, and this can readily be determined by examining a transverse section; the more of this hard tissue there is present, the less palatable is the grass to stock. The next and largest section of the book gives a general sketch of the grasslands of South Africa, and their development, and the last section deals with the economic applications of grasses, including the effect on the grass veld of grass-burning and stock-grazing, the feeding value of different types of grassland and grasses, the cultivation of grasses and the relation between grasses and soil erosion. A list of English, Dutch, Zulu and Sesuto names of grasses is given in an appendix.

Manual of Tree Diseases. By W. Howard Rankin, A.B., Ph.D. Pp. xx + 398, Crown 8vo. (New York: The Macmillan Company; London: Macmillan & Co., Ltd., 1918.) Price 12*s.* 6*d.* net; post free, United Kingdom 13*s.*, abroad 13*s.* 3*d.*

This volume is one of the useful series of "Rural Manuals" edited by L. H. Bailey. It deals with diseases of forest, shade, and ornamental trees of the United States only, but nevertheless will be welcomed by all interested in the subject, as it collects together for the first time the voluminous literature scattered through the publications of the United States Department of Agriculture, and the State Experiment Stations, and numerous scientific journals. The first four chapters deal with diseases which are more or less common to all kinds of trees, arranged according to the part affected, viz. seedling, leaf, stem and root. The remainder of the book is devoted mainly to diseases attacking different trees, the latter being arranged alphabetically under their common names. Most of the diseases described are due to the action of fungi, but injuries caused through

parasitic flowering plants, frost, drought, high temperature, smoke and gas, are also considered. Special attention is given to the symptoms of the disease and methods of control, and very little is said about the organism which causes the disease, except in so far as such particulars are necessary to a correct understanding of the way in which the disease is spread, and the means by which it is controlled. There is much to be said in favour of this method of treatment, but an outline of the life-histories of some typical fungi and their mode of nutrition would prove useful to those readers who have not been through a course of botanical study. References to original papers are given after the description of the disease in most cases, and a list of general treatises on tree diseases is appended to the book. There are seventy illustrations, and a very full index. A short glossary of technical terms is included in an appendix.

The Mica Miner's and Prospector's Guide. By A. A. C. Dickson. Pp. viii + 50, Crown 8vo. (London: E. and F. N. Spon, Ltd., 1919.) Price 4*s*. 6*d*. net; post free, United Kingdom and abroad 4*s*. 9*d*.

This is a handy little book, suitable for the pocket, written by one who has had a large practical experience in mica-mining at the Kodarma mines in India. Illustrated descriptions of the mines are given in some detail. Timbering, drilling, pumping, hoisting and haulage, ventilation and lighting are dealt with briefly in separate sections. A short account of the mining geology of mica deposits is given. Advice to mica miners and a useful glossary conclude the book.

Mica mining is regarded by many as a necessarily fortuitous industry. The author is convinced, however, from his experience that this is not so. He pleads for the careful observation of indicators, where these exist, in tracing the connection between mica-shoots across barren ground; and emphasises the importance of systematic procedure in mining methods generally. This is clearly the right sort of advice; and nothing could be more welcome than his assurance that such procedure leads to successful results, backed as this assurance is by much practical experience.

The book is one that should be read by all who are interested in mica mining, and it is worthy of note that at the time of writing (February 1918) the author had in preparation a larger book, giving fuller details, which he hoped to have ready early in 1919.

BOOKS RECEIVED

Australia: Problems and Prospects. By The Hon. Sir Charles G. Wade, K.C. Pp. 111, Med. 8vo. (Oxford: Clarendon Press, 1919.) Price 4*s.* net; post free, United Kingdom and abroad 4*s.* 4*d.*

The Planting, Cultivation and Expression of Coconuts, Kernels, Cacao and Edible Vegetable Oils and Seeds of Commerce. By H. Osman Newland. Pp. 111, Demy 8vo. (London: Charles Griffin & Co., Ltd., 1919.) Price 6*s.* net; post free, United Kingdom and abroad 6*s.* 4*d.*

Sugar Beet Seed: History and Development. By Truman G. Palmer. Pp. xv + 120, Crown 8vo. (New York: John Wiley & Sons; London: Chapman & Hall, Ltd., 1918.) Price 6*s.* 6*d.* net; post free, United Kingdom and abroad 6*s.* 10*d.*

Aeroplane Timbers: Their Structure, Formation and Mechanical and Commercial Properties. By Gilbert R. Keen. Pp. x + 78, Demy 8vo. (London: William Rider & Son, Ltd., 1919.) Price 6*s.* net; post free, United Kingdom and abroad 6*s.* 4*d.*

The Silk Industry and Trade. By Ratan C. Rawlley, M.A., M.Sc. (Econ.). Pp. xvi + 172, Demy 8vo. (London: P. S. King & Son, Ltd., 1919.) Price 10*s.* 6*d.*; post free, United Kingdom and abroad 11*s.*

The Mineral Deposits of South America. By B. J. Miller, Ph.D., and J. T. Singewald, Jr., Ph.D. Pp. ix + 598, Med. 8vo. (New York: McGraw-Hill Book Co.; London: Hill Publishing Co., Ltd., 1919.) Price 25*s.* net; post free, United Kingdom 25*s.* 6*d.*, abroad 25*s.* 10*d.*

The Analysis of Minerals and Ores of the Rarer Elements. By W. R. Schoeller, Ph.D., and A. R. Powell. Pp. x + 239, Med. 8vo. (London: Charles Griffin & Co., Ltd., 1919.) Price 16*s.* net; post free, United Kingdom and abroad 16*s.* 6*d.*

A Treatise on British Mineral Oil. Edited by J. Arthur Greene. Pp. xi + 233, Med. 8vo. (London: Charles Griffin & Co., Ltd., 1919.) Price 21*s.* net; post free, United Kingdom and abroad 21*s.* 6*d.*

The Preparation of Substances important in Agriculture. 3rd ed. By Charles A. Peters, Ph.D. Pp. vii + 81, Crown 8vo. (New York: John Wiley & Sons; London: Chapman & Hall, Ltd., 1919.) Price 4*s.* net; post free, United Kingdom and abroad, 4*s.* 3*d.*

REPORTS OF RECENT INVESTIGATIONS AT THE IMPERIAL INSTITUTE

The following summaries have been prepared from a selection of the Reports made by the Director of the Imperial Institute to the Dominion, Colonial and Indian Governments.

THE MECHANICAL PROPERTIES OF WEST AFRICAN "POOLI" TIMBER

In 1917 a supply of "pooli" timber was forwarded to the Imperial Institute from Sierra Leone with a request that it should be submitted to mechanical tests in order to ascertain its strength and value for constructional purposes in comparison with some of the commoner woods such as pitch pine and deal. It was stated that the timber was derived from *Cordia platythyrsa*, Baker. This is a tree 30–80 ft. high, belonging to the natural order Boraginaceæ. It is found in the Gaboon, Nigeria and Cameroons, as well as in Sierra Leone. According to Chevalier the wood is used to make tomtoms.

The samples received at the Imperial Institute consisted of two planks about 12 ft. long, 10 in. wide, and 1 to 1⅛ in. in thickness, and two bars about 12 ft. long and 3½ by 3 in. in section.

The timber was submitted to working tests with the following results:

The samples were well seasoned, and specimen pieces showed little sign of warpage after cutting. In colour and figure the wood resembled a light-coloured mahogany. The wood saws and planes freely and turns fairly well; it takes nails well without splitting, and gives a very strong glued joint. The wood is smooth after planing and requires very little scraping to bring it to a polishing

BENDING TESTS

Test No.	Descripton.	Dimensions.			Deflection.								Breaking load.	Modulus of rupture.[1]	Ultimate maximum stress.	Remarks.
		Span.	Breadth.	Depth.	Load in pounds.											
					200	400	600	800	1,000	1,200	1,400	1,600				
		in.	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*lb.*	*lb. per sq. in.*	*tons per sq. in.*	
1	Specimens cut from plank 10 in. wide and 1 in. thick	36	9·0	0·80	0·48	0·96	1·45	1·92	2·55	—	—	—	1,180	11,060	5·0	Fracture stringy.
2		36	10·0	0·89	0·28	0·56	0·86	1·12	1·40	1·69	2·03	2·53	1,680	11,450	5·1	
					Load in pounds.											
					1,000	2,000	3,000	4,000	5,000							
					in.	*in.*	*in.*	*in.*	*in.*							
3	Specimens cut from bar 3½ in. by 3 in. . . .	36	2·48	3·51	0·09	0·18	0·28	0·40	0·53				5,500	9,720	4·3	Fracture rather short.
4		36	2·57	3·42	0·09	0·18	0·27	0·36	0·47				5,930	10,650	4·7	

[1] *Modulus of rupture* $= \frac{3WL_1}{2BD^2}$, *where W = the breaking load, L = the span, B = the breadth and D = the depth of test piece.*

CRUSHING TESTS

Test No.	Description.	Dimensions.		Sectional area.	Crushing strength.		
		Height.	*Section.*		Total.	Per square inch.	
		in.	*in.*	*sq. in.*	*lb.*	*lb.*	*tons.*
5	Specimens cut from bar 3½ in. by 3 in.	7·80	2·63 × 3·45	9·07	55,500	6,120	2·73
6		7·75	2·63 × 3·45	9·07	53,400	5,890	2·63

SHEARING TESTS

Specimens tested in double shear length-wise of grain

Test No.	Description.	Dimensions (for shear).	Shearing area.	Shearing strength.		
				Total.	Per square inch.	
		in. *in.*	*sq. in.*	*lb.*	*lb.*	*tons.*
7	Specimens cut from plank 10 in. wide, 1 in. thick	3·80 × 0·85 (2)	6·46	7,300	1,136	0·50
8		3·74 × 0·87 (2)	6·51	7,100	1,090	0·49

surface; it takes polish freely, but can be brought to a good finish with ordinary French polish.

The timber was submitted to mechanical tests in order to determine its transverse, crushing and shearing strengths. The results obtained are shown in the tables on pp. 278–9.

The coniferous timbers used in the United Kingdom may be taken as giving the following average figures in mechanical tests:

	tons per sq. in.
Crushing strength	2·5
Shearing ,,	0·3
Bending ,, (ultimate maximum strength)	3·5

In comparison with these figures it will be seen that the pooli timber is equal to the average in crushing strength and better than the average as regards bending and shearing.

The planks and bars of the timber showed considerable variation in the weight per cubic foot. A specimen cut from one of the planks gave a value of 28·4 lb. per cubic ft.; two pieces cut from one of the bars gave 24·7 lb. and 26·1 lb. per cubic ft. respectively, whilst a piece cut from the other bar gave 19·6 lb. per cubic ft. The density of the wood is therefore about the same as that of white pine and considerably less than that of pitch pine.

The timber was reported on by the Imperial Institute Advisory Committee on Timbers, who regarded it as of good quality and appearance, and considered that it might find a market in the United Kingdom as a substitute for certain grades of mahogany.

The Committee on Timbers suggested that in view of the promising nature of this timber further enquiries should be made as to the possibility of exporting it from Sierra Leone if larger supplies become available. It seems probable that if the planting of the timber can be undertaken, as suggested by the Conservator of Forests, a good market should eventually be found for the wood in the United Kingdom.

PLANT ASHES AS A SOURCE OF POTASH

At one time all the potash of commerce was obtained by burning plants and suitably treating the ash produced, but this source sank to minor importance when the deposits of potash salts in the Stassfurt district began to be worked. The industry still survived, however, in Canada, where pot-ashes were made from waste lumber, and in Russia, where potassium carbonate was prepared from sunflower ash. Even before the war pot-ashes or potash salts figured in the export trade of both these countries. During the war, countries which had obtained their supplies of potash from Germany were compelled to seek new sources. These were dealt with fully in *The World's Supply of Potash*, issued by the Imperial Institute in 1915, a new edition of which is now in course of preparation, and it is proposed in the present article to deal only with certain plant ashes which have been suggested recently as possible sources of potash salts or for use as potash manures.

Wood Ashes from the East Africa Protectorate

Owing to the scarcity and high price of coal in East Africa wood is the chief fuel used on the Uganda Railway, and large quantities of ashes are produced. At the suggestion of the Imperial Institute samples of the ashes were forwarded for examination with a view to ascertaining their value as sources of potash.

The samples, which weighed about 28 lb. each, were as follows :

No. 1. White chestnut wood ash.
No. 2. Black wattle wood ash.
No. 3. Olive wood ash.

All three samples consisted of pale grey ash containing a small quantity of sandy matter.

The ashes were submitted to chemical examination at the Imperial Institute with the following results, which are expressed on the original ash :

		No. 1. Chestnut wood ash.	No. 2. Wattle wood ash.	No. 3. Olive wood ash.
		Per cent.	*Per cent.*	*Per cent.*
Moisture		1·77	0·80	1·44
Combined water		4·59	3·61	7·42
Matter soluble in water:				
Potash	K_2O	5·38	6·98	2·13
Soda	Na_2O	1·34	1·24	0·66
Chlorides, expressed as chlorine	Cl	trace	0·23	trace
Sulphates, expressed as sulphuric acid	SO_3	trace	0·74	0·70
Equivalent to:				
Potassium chloride	KCl	trace	0·49	trace
,, sulphate	K_2SO_4	trace	1·61	1·52
,, carbonate	K_2CO_3	7·89	8·77	1·92
Sodium carbonate	Na_2CO_3	2·29	2·10	1·13
Matter insoluble in water:				
Lime (total)	CaO	49·98	45·80	52·32
Phosphates, expressed as phosphoric acid	P_2O_5	0·65	2·11	1·84
Potash	K_2O	0·26	0·78	0·04
Soda	Na_2O	1·71	0·80	1·32
Equivalent to:				
Calcium carbonate[1]	$CaCO_3$	87·9	77·5	89·5
Calcium phosphate	$Ca_3P_2O_8$	1·4	4·6	4·0
[1] *Part of the lime was present in the samples as quick-lime (CaO), the quantities of the latter being*		12·31	11·23	23·86

If the soluble matter present in the three ashes were extracted with water and the solution evaporated to dryness, the "crude potashes" thus obtained would have the following approximate composition:

		Crude potashes from:		
		Chestnut wood ash.	Wattle wood ash.	Olive wood ash.
		Per cent.	*Per cent.*	*Per cent.*
Potassium chloride	KCl	trace	4	trace
,, sulphate	K_2SO_4	trace	12	33
,, carbonate[1]	K_2CO_3	77·5	68	42
Sodium carbonate	Na_2CO_3	22·5	16	25
Yield of dry crude potashes per ton of ash treated		*lb.* 228	291	102

[1] *A fair proportion of this would be present as potassium hydroxide (KOH).*

The above figures are only roughly approximate, and assume (1) the removal of any lime dissolved on extracting the ash with water, and (2) that all the potassium hydroxide formed during the burning of the ash will be

converted into carbonate, which however would not be the case in practice.

The following analyses of commercial potashes will be of interest for comparison with the preceding figures :

		Commercial crude potashes ("Montreal ashes"). (1)	(2)	(3)	Sunflower stalk ash.
		Per cent.	Per cent.	Per cent.	Per cent.
[1] Potassium carbonate	K_2CO_3	26·16	21·71	46·13	36·86
[1] „ hydroxide	KOH	36·50	30·63	6·14	
„ sulphate	K_2SO_4	10·40	9·18	20·53	1·21
„ chloride	KCl	1·68	6·13	7·63	4·00
Sodium carbonate	Na_2CO_3	2·84	8·52	17·81	2·18
[1] *Equivalent to potassium carbonate*	K_2CO_3	71·1	59·4	53·9	

The residues remaining after extracting the soluble matter from the three East African ashes would, when dry, have approximately the following composition :

		Residue from : Chestnut wood ash.	Wattle wood ash.	Olive wood ash.
		Per cent.	*Per cent.*	*Per cent.*
Calcium carbonate[1]	$CaCO_3$	96·3	92·7	94·2
„ phosphate	$Ca_3P_2O_8$	1·4	5·5	4·2
Potash	K_2O	0·3	0·9	0·04
Soda	Na_2O	1·8	0·9	1·4

[1] *Including the quick-lime present* (CaO), *expressed as* $CaCO_3$.

These insoluble residues would be of value for use locally on land deficient in lime and phosphoric acid.

The crude wood ashes, represented by these three samples, would form valuable manures for use in East Africa, on account of the high percentage of potash, lime and phosphoric acid which they contain. Owing to the high temperature at which the ashes were produced, they contain a considerable quantity of caustic lime, which is of far more value for addition to the soil than calcium carbonate.

It is unlikely that the crude ashes could be exported remuneratively to the United Kingdom as a source of potash, but in the case of the chestnut and wattle wood ashes the soluble matter might be extracted with water and the solution evaporated, as described above, and the "potashes" thus obtained exported. Unfortunately,

however, these potashes contain considerable proportions of sodium carbonate (see approximate composition given on p. 282), which is an objectionable feature and would reduce their value in comparison with potashes from other sources. The olive wood ash probably does not contain enough potash to be remuneratively extracted, and in this case the ash could only be employed in the crude form as a fertiliser.

Before the war 90 per cent. potassium carbonate made in Russia from sunflower stalk ash was sold in the United Kingdom at £14 to £14 10*s*. per ton ex store, and as this material is much superior in composition to the crude potashes from the East African woods it will be seen that the latter would not be likely to fetch a very high price under normal conditions.

Before taking further action in this matter it would be desirable to know the approximate quantities of the crude ashes of these woods which are obtainable in East Africa and whether the preparation of "potashes" could be undertaken on a commercial scale. It will then be possible to form an estimate of the amount of potashes likely to be available and to get valuations of the products under more normal conditions than those which obtain at present.

Ash of the Blue Gum Tree from Tasmania

A sample of ash prepared from very young leaves and twigs of the blue gum tree (*Eucalyptus globulus*) was forwarded to the Imperial Institute by the Director of Agriculture at Hobart in 1917.

The sample consisted of a well-burnt grey ash, containing a little sand.

The material, which contained 5·01 per cent. of moisture and combined water, was submitted to chemical examination with the following results :

		Per cent. on the original ash.
Matter soluble in water :		
Potash	K_2O	10·12
Soda	Na_2O	4·31
Chlorides, expressed as chlorine	Cl	1·78
Sulphates, expressed as sulphuric acid	SO_3	1·00

		Per cent. on the original ash.
Matter insoluble in water:		
Lime	CaO	31·54
Magnesia	MgO	6·00
Potash	K_2O	0·40
Soda	Na_2O	0·80
Sulphates, expressed as sulphuric acid	SO_3	0·45
Phosphates, expressed as phosphoric acid	P_2O_5	2·35

The results of the analysis indicate that the original ash contains the following constituents in the proportions shown:

		Per cent. of total ash.
Potassium chloride	KCl	3·74
,, sulphate	K_2SO_4	2·28
,, carbonate	K_2CO_3	9·53 [1]
Sodium carbonate	Na_2CO_3	7·32
Calcium phosphate	$Ca_3P_2O_8$	5·12
Calcium carbonate	$CaCO_3$	51·40 [2]

[1] *Part of this was present as the hydroxide (KOH).*
[2] *Part of this was present as caustic lime (CaO).*

These results indicate that the ash would be a useful manure on account of the soluble potash salts which it contains, and that the lime and phosphoric acid in the insoluble matter would add to its value for this purpose. The quantity of sodium carbonate in the ash is somewhat high, and care would have to be exercised in applying the ash to young plants sensitive to alkali. For most crops injury is not likely to result from the application of the ash to the soil in the quantities usually recommended for potash manures.

The percentage of potash soluble in water is considerably higher than the amount found in most plant ashes made from mature woods. This feature is characteristic of the ash of young twigs and leaves.

It would not be profitable to export this ash to the United Kingdom at the present time, owing to the high cost of freight, but it might be remunerative to extract the matter soluble in water and ship it to the United Kingdom for sale as crude potashes. It is not possible, however, to fix any definite price for the product owing to the difference in composition between the soluble portion and the potashes of commerce, notably as regards the amount of sodium carbonate present.

SUNFLOWER ASH FROM RHODESIA

An account of the results of examination of ash prepared at the Imperial Institute from Rhodesian sunflower stems has already been published in this BULLETIN (1917, **15**, 333). A sample of ash prepared in Rhodesia by burning sunflower stalks after removal of the heads was examined in 1918.

The sample consisted of a dark grey ash free from large fused particles.

The ash as received contained 23 per cent. of moisture. It was extracted with water and the soluble and insoluble portions were then submitted to partial analysis with the following results:

		Per cent. on the ash as received.	*Per cent. on the dry ash.*
Portion soluble in water:			
Potash	K_2O	28·28	36·73
Soda	Na_2O	1·28	1·66
Lime	CaO	nil	nil
Magnesia	MgO	nil	nil
Sulphuric acid	SO_3	0·56	0·73
Chlorine	Cl	1·91	2·48
Phosphoric acid	P_2O_5	nil	nil
Portion insoluble in water:			
Potash	K_2O	0·17	0·22
Soda	Na_2O	0·63	0·82
Lime	CaO	14·55	18·90
Phosphoric acid	P_2O_5	c·53	0·69

The percentages of potash and phosphoric acid in this sample of sunflower ash are considerably lower than the amounts present in the sample of ash previously prepared at the Imperial Institute from Rhodesian sunflower stalks, which contained 49·6 per cent. of potash and 1·5 per cent. of phosphoric acid in the dry material.

The analytical results indicate that the potash in this sample of ash is largely in the form of carbonate with a little chloride and sulphate, and that it could be readily extracted by water, only a very small quantity remaining insoluble.

The portion soluble in water and recoverable by evaporation would have approximately the following composition:

			Per cent.
Potassium carbonate (by difference)[1]	K_2CO_3	. . .	83·4
,, sulphate	K_2SO_4	. . .	2·7
,, chloride	KCl	. . .	9·0
Sodium carbonate	Na_2CO_3	. . .	4·9

[1] *That is, assuming that all the potassium salts, other than chloride and sulphate, consist of carbonate.*

The soluble portion of the original ash would compare with the crude potassium carbonate prepared in Russia from sunflower ash.

The insoluble residue remaining after the extraction of the soluble salts from the original ash would have approximately the following composition when dry :

			Per cent.
Lime	CaO	. . . . .	41·7[1]
Potash	K_2O	. . . . .	0·5
Soda	Na_2O	. . . . .	1·8
Phosphoric acid	P_2O_5	. . . . .	1·6[1]

[1] *Equivalent to :*

Calcium phosphate	$Ca_3P_2O_8$	. . . . .	3·4
,, *carbonate*	$CaCO_3$	. . . . .	71·3

These figures indicate that the residue would be useful as a manure for soils deficient in calcium carbonate. The calcium phosphate would also be of manurial value, but the quantity present is too small to add materially to the value of the residue as a whole.

The present sample of sunflower ash contains less potash than a sample prepared at the Imperial Institute from Rhodesian sunflower stalks. It consists principally of potassium and calcium carbonates with small amounts of potassium chloride and sulphate and of sodium carbonate. The crude ash, if extracted with water and the solution evaporated to dryness, would yield a salt rich in potassium carbonate, whilst the insoluble residue, which consists chiefly of calcium carbonate together with a small amount of calcium phosphate, could be used as a lime dressing for soils.

There would be a ready market in the United Kingdom for any supplies of crude potassium carbonate prepared as described above from sunflower ash, and information has been requested as to whether it would be possible to

supply such material in commercial quantities from Rhodesia.

Ash of the Leaves and Wood of the African Tragacanth

Samples of the dry leaves and wood of the African tragacanth (*Sterculia Tragacantha*, Lindl.) were forwarded from Sierra Leone in 1917, and the ashes have been examined in order to ascertain their value as a source of potash. It was stated that the ash of the plant is used locally for soap-making. A quantity of bark was present on the sample of wood received.

The quantities of total ash yielded by the two samples and the amounts of potash present are given in the following table, together with the average amounts of potash recorded for certain wood ashes and other materials :

	Total ash.	Potash (K_2O) in the ash. Expressed on the ash.	Potash (K_2O) in the ash. Expressed on original material.
	Per cent.	*Per cent.*	*Per cent.*
Sterculia Tragacantha leaves	6·165	12·26	0·755 [1]
,, ,, wood and bark	2·671	18·50	0·494 [1]
Pine wood	—	—	0·045
Beech wood	—	—	0·145
Birch wood	—	—	0·057
Willow wood	—	—	0·285
Maple wood	—	—	0·124
Maple bark	—	—	0·686
Elm wood	—	—	0·390
Sunflower stalks (dry)	10·7	—	5·213

[1] *Potash soluble in water.*

The amounts of certain other constituents in the two samples of Sterculia ash were also determined, with the following results :

		Ash from leaves.	Ash from wood and bark.
		Per cent.	*Per cent.*
Constituents soluble in water :			
Potash	K_2O	12·26	18·50
Soda	Na_2O	1·78	2·52
Sulphuric acid	SO_3	2·31	1·86
Chlorine	Cl	trace	trace
Constituents insoluble in water :			
Lime	CaO	33·47	28·80
Phosphoric acid	P_2O_5	4·72	1·60

The above results show that the ash from the wood and bark contains a larger percentage of soluble potash than the ash from the leaves.

The residues remaining after the extraction of the water-soluble matter from the two ashes would contain approximately the following amounts of lime and phosphoric acid, and might be utilised for manuring soils deficient in these constituents :

		Residue of ash from the leaves.	Residue of ash from the wood and bark.
		Per cent.	*Per cent.*
Lime	CaO	49·8	46·9
Phosphoric acid	P_2O_5	7·2	2·6
Eqivalent to :			
Calcium carbonate	$CaCO_3$	75·2	78·5
Calcium phosphate	$Ca_3P_2O_8$	14·9	5·5

The wood and bark of the African tragacanth evidently form a more valuable source of water-soluble potash than the leaves, but both materials compare favourably with the majority of plant products used as sources of potash. The ashes could be used either as a crude potash manure or potassium carbonate could be prepared from them by leaching with water and evaporating the solution. If the latter method were adopted, the insoluble residue remaining after the operation could be used as a manure for soils deficient in calcium carbonate and phosphates.

THE QUALITY OF NIGERIAN COCOA

The production of cocoa in Nigeria has increased rapidly in recent years, but the output is still far below that of the neighbouring colony of the Gold Coast. The exports rose from 687 cwts. in 1898 to 72,428 cwts. in 1913 ; during the war the increase was still more rapid, and in 1917 308,841 cwts. of a value of £500,000 were exported. In the latter year Nigeria was the third most important cocoa-producing country in the Empire, its output being only exceeded by those of the Gold Coast and Trinidad. Further particulars relating to the in-

dustry will be found in the article on "Cocoa Production in the British Empire" in this BULLETIN (1919, **17**, 53).

Much of the cocoa exported from Nigeria is inferior in quality to ordinary Gold Coast ("Accra") cocoa. Attempts are being made by the Department of Agriculture to improve the quality, by means of experiments on fermentation and drying and by demonstrations on the best methods of preparing the product carried out in the principal cocoa-growing districts. The movement is being assisted by local merchants, who pay a premium on cocoa prepared by natives in the manner demonstrated. Samples of cocoa prepared in some of the earlier experiments have already been described in this BULLETIN (1914, **12**, 213; 1915, **13**, 553). In 1918 further samples were examined at the Imperial Institute, the series including cocoa which had been specially prepared to demonstrate the effects of different periods of fermentation, and samples prepared by natives. Some of the latter represented types of cocoa purchased in the ordinary course of business by merchants.

The samples were as follows:

Nos. 1, 2 *and* 3.—These samples were taken from three fractions of a single cure. The beans from 5,270 pods were fermented in one box and were turned twice during the fermentation period. The beans were then divided into three approximately equal portions, one of which (No. 1) was immediately put out to dry, another (No. 2) was washed before being spread out to dry, and the third (No. 3) was put back for two days and six hours' extra fermentation before being finally spread out to dry. Sample No. 3 was actually fermented 9 days and 15 hours.

No. 4.—This was taken from a 6-day fermentation carried out without special European supervision.

No. 5.—This sample was obtained from one of the European factories, which during the 1917 season bought native-fermented cocoa under the Government premium scheme, the premium being 2*s.* 4*d.* per cwt. at the time of purchase.

No. 6.—This was prepared by a native member of the Ibadan Agricultural Society.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.	No. 11.
Colour of break .	Chocolate brown chiefly; some purplish-brown.	Chocolate brown.	Chocolate brown.	Chiefly purplish-brown.	Variable. Chocolate brown to purplish-brown.	Variable. Chocolate brown to purplish-brown.	Chiefly purplish-brown.	Variable. Purplish-brown to brown.	Chiefly purplish-brown; some chocolate brown.	Chiefly purplish-brown; some chocolate brown.	Purplish- or greyish-brown; in a few cases brown.
Average weight of 100 beans in grams . .	95·1	89·7	111·5	105·1	103·6	108·7	102·6	94·5	92·1	104·1	103·9
Number of beans to fill a cylinder of 200 cc. capacity . . .	119	121	95	120	109	100	111	120	120	108	116
Percentage of husk	13·5	7·8	12·1	12·0	12·8	10·9	10·5	13·2	12·5	10·2	11·0

Analysis of husked Beans

	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture . .	4·9	4·9	4·9	4·5	4·8	5·0	5·1	5·3	5·1	5·1	4·9
Fat . . .	49·4	49·5	50·5	52·6	53·5	51·7	52·0	50·6	50·8	52·2	52·8
Total alkaloids .	1·40	1·27	1·34	1·35	1·36	1·47	1·57	1·52	1·60	1·74	1·80
Ash. . . .	2·9	2·8	2·8	2·7	2·6	2·6	3·0	3·0	3·0	2·8	2·8

Nos. 7 and 8.—These were small samples, procured from a European factory in Ibadan and represented average non-premium purchases.

Nos. 9 and 10.—These were also obtained from the ordinary purchases of a local trading firm.

No. 11.—This was stated to represent unfermented cocoa from the Oshogbo District, procured from a trading firm. The beans received at the Imperial Institute, however, appeared to have undergone partial fermentation.

The samples were examined with the results shown in the tables on p. 291.

The beans are somewhat smaller than those of the previous samples from Nigeria examined at the Imperial Institute (*loc. cit.*). The weight of 100 beans in the previous samples varied from 111 to 147 grams as compared with 89·7 to 111·5 grams in the present specimens.

The percentages of fat and ash vary but slightly throughout the entire series, and agree with the corresponding figures obtained for the earlier samples. The yields of alkaloid are also normal and fairly constant, the unfermented sample from Oshogbo (No. 11) showing the highest figure, viz. 1·80 per cent.

In order to obtain expert opinion on the market value of the cocoas, samples were submitted to two firms of manufacturers. One firm based their valuation on the appearance of the samples and the second on the character of the liquor made from the beans, after they had been roasted and ground.

The descriptions and valuations supplied by the first firm were as follows :

Sample.	*Description.*	*Value per cwt.* s.	d.
No. 1.	A fine cocoa, evenly fermented and carefully dried . .	64	0
No. 2.	Similar to No. 1, but has been washed. This is rather a detriment than otherwise, as it weakens the shell and renders the bean liable to depreciation	63	0
No. 3.	The extra fermentation shows no advantage except that the beans have a bolder appearance	64	6
No. 4.	The best sample from a market point of view; fine and evenly fermented	65	0
No. 5.	Slightly weathered and probably mixed. Not so evenly fermented as Nos. 1, 2 and 3	63	6

Sample.	Description.	Value per cwt. s. d.
No. 6.	Contains a small percentage of unfermented and germinated beans. Not so good as No. 5	62 6
No. 7.	Badly fermented and mouldy	58 0
No. 8.	Very poor indeed	55 0
No. 9.	Badly fermented and partly mouldy	61 0
No. 10.	Not so clean in appearance as No. 9, but showing a good break and better fermented	62 0
No. 11.	Typical Nigerian cocoa, washed, partly or irregularly fermented and evidently mixed	60 0

The firm stated that the samples indicate that marked progress is being made in Nigeria in the cultivation and preparation of cocoa, although in their opinion none of the present samples is quite equal in quality to the standard of fine Accra.

The results obtained by the second firm were as follows :

Sample.	Description.
No. 1.	The best cocoa of the series, having a clean, slightly acid, pleasant and full taste. The flavour lies between a good San Thomé and a well-fermented Grenada.
No. 2.	Not unlike No. 1, but slightly cruder and duller in flavour.
No. 3.	Inferior to Nos. 1 and 2. Dull and muddy in flavour.
No. 4.	Clean, but with a thin, acid, "green" taste. Not to be compared with Nos. 1 and 2.
No. 5.	Acrid and disagreeable in taste. Probably butyric fermentation was set up.
No. 6.	Has an unclean flavour with an acrid back-taste, though better than No. 5.
Nos. 7 and 8.	Too small to allow of proper tests.
No. 9.	Unpleasant cocoa with a muddy and acrid flavour.
No. 10.	Better than No. 9, but dull and rather smoky in flavour.
No. 11.	Unfermented "green" cocoa, with a strong, astringent back taste. Clean and suggesting a green Para cocoa.

This firm stated that taking the 1914 value of fine Grenada cocoa at 72*s.* per cwt., fine San Thomé at 72*s.*, Accra F.A.Q. at 59*s.* to 62*s.*, and Accra fermented at 62*s.* to 65*s.*, the best of these Nigerian cocoas (Sample No. 1, in their opinion) would be worth 72*s.* and the worst (equal to the lowest Accra cocoa) 59*s.* per cwt. in the United Kingdom.

It will be noticed that the reports of the two firms to whom these samples were submitted show a divergence of opinion as to which is the best sample of the series.

This is no doubt to be attributed to the different methods of testing adopted in the two cases.

The results of the present investigation show that some of these cocoas (Samples Nos. 1, 2, 3 and 4) are of promising character, and there is no doubt that Nigerian cocoa, if carefully prepared, is of good quality and should find a ready market in the United Kingdom.

The extra fermentation received by Sample No. 3 was not regarded as an advantage by either of the firms of manufacturers to whom the samples were submitted, and the washing of Sample No. 2 did not result in any improvement of the quality. The two samples, Nos. 1 and 4, which were pronounced to be the best of the series by the two manufacturers were fermented for 7 days 9 hours and 6 days respectively.

THE COAGULATED LATEX OF THE SOUTH AMERICAN COW-TREE

A sample of coagulated latex derived from a tree believed to be *Galactodendron utile*, H. B. and K. (*Brosimum Galactodendron*, Don.) was received from the Agricultural Adviser to the Government of Colombia early in 1918. It was stated that the material was being exported to the United States for the manufacture of chewing-gum. *B. Galactodendron* is the well-known cow-tree of the Cordilleras. It is a large tree, sometimes reaching a height of 100 ft., and belongs to the Natural Order Moraceæ, being closely related to the Castilloa rubber tree and *Ficus elastica*. When incisions are made in the trunk or branches there is a copious flow of white, somewhat viscid latex, which closely resembles cow's milk in appearance and flavour. This fluid is said to possess considerable nutritive value and is largely used by the natives as a food. On standing it becomes yellow and gradually thickens to the consistency of cheese.

The sample sent to the Imperial Institute consisted of a block of gutta-like material of a pale buff tint. The material was hard and somewhat friable, but could easily

be cut with a knife ; under pressure in the hand it became somewhat softer and malleable.

The material was examined at the Imperial Institute with the following results :

	Expressed on material as received. *Per cent.*	Expressed on the dry material. *Per cent.*
Moisture	8·4	—
Resin	83·2	90·8
Impurities	2·9	3·1
Including :		
Protein	0·23	—
Ash	0·14	—
"Gutta" (by difference)	5·5	6·1

The resin (*i.e.* the matter soluble in acetone) chiefly consisted of an opaque material of light brown colour together with a darker brown resinous-looking body. The residual "gutta" left after the removal of the resin was very soft and plastic at ordinary temperatures.

The above results show that this Galactodendron latex contains a small amount of "gutta" and a large proportion of resin. When slowly warmed it becomes sufficiently soft and plastic to be moulded without being sticky, and on cooling it becomes firm but distinctly brittle, as might be expected from the large amount of resin present.

The material is too brittle and resinous to be of use as a substitute for balata or gutta-percha, but it exhibits considerable resemblance to pontianac, which is largely used in rubber compounding for adding plasticity to the mixings.

A firm of manufacturers to whom a sample of the Galactodendron latex was submitted considered that the material could be used in the rubber industry as a substitute for pontianac. In their opinion the material would even be preferable to pontianac, being less brittle and more rubber-like in properties, and they valued it at 1*s.* 2*d.* per lb. in the United Kingdom in comparison with washed dried pontianac at 1*s.* per lb.

This Galactodendron latex differs in composition from "chicle gum," derived from *Achras sapota*, which is largely used for the manufacture of chewing-gum, as it

contains more resin and less gutta. It is, however, similar in physical characters and becomes plastic when chewed; further, it is of pale colour and free from any appreciable amount of bark or mineral matter, so that it should be readily saleable for the manufacture of chewing-gum. A firm of brokers classed the sample as "gum chicle," but stated that, owing to the difficulty of obtaining adequate supplies of sugar, there was only a small demand in the United Kingdom at the time for such material for confectionery purposes (November 1918). They considered that its value would be about 1*s.* 9*d.* to 2*s.* per lb., but added that large consignments could not be recommended.

A NEW RESIN FROM SOUTH AMERICA

A sample of "cuica" or "quika" resin was forwarded for examination by the Agricultural Adviser to the Government of Colombia, in November 1917. This material is derived from *Cercidium spinosum*, Tulasne (Nat. Ord. Leguminosæ), a small tree related to the Cæsalpinias, and growing abundantly in certain parts of the Goajira Peninsula, Colombia (Dawe, *Account of a Journey down the Magdalena River, through the Magdalena Province and the Peninsula of Goajira*: Ministry of Agriculture and Commerce, Bogotá, Colombia). It is stated that the resin forms a layer on the trunk and branches of the tree, and that the roots, when exposed to the air, also become covered with resin.

The sample received at the Imperial Institute consisted of coarsely ground, translucent, yellow resin, containing brown particles of bark.

The resin as received was examined with the following results:

Specific gravity at 17°/17° C.		1·079
Moisture	*per cent.*	1·3
Matter soluble in water	*per cent.*	0·6
Matter soluble in hot alcohol	*per cent.*	90·6[1]
Ash	*per cent.*	3·0

[1] *The remaining* 9·4 *per cent., insoluble in hot alcohol, consisted chiefly of bark.*

The resin contained no volatile oil.

The resin was purified by extracting the crude material with hot alcohol, filtering while hot and removing the alcohol by distillation. The following results were obtained on examining the purified resin :

Melting-point	77° C.
Acid value[1]	23·8
Saponification value[1] . . .	84·1
Iodine value . . . *per cent.*	85·8

[1] *Milligrams of potash for* 1 *gram of resin.*

The resin was soluble in boiling alcohol, but the solution deposited a fairly large amount of a white precipitate on cooling. The resin was partially soluble in ether; entirely soluble in benzene and in chloroform ; and almost entirely soluble in turpentine oil, the solution in this case being slightly opalescent.

Experiments conducted at the Imperial Institute showed that the resin is not well suited for making spirit varnish, as it possesses the defect of being partially insoluble in cold alcohol. A solution of the purified resin in an equal weight of alcohol was dull and "muddy" when cold, but when applied to wood gave a fairly hard and brilliant coat. A varnish made of one part of the purified resin to one part of turpentine gave a clear, pale straw-coloured coat, but dried very slowly, the surface being still sticky at the end of 14 days.

Samples of the resin were submitted to firms interested in varnish-making materials, but the general opinion was that the resin would not be suitable for the preparation of spirit, turpentine or oil varnishes. The varnish made from the resin did not dry in a reasonable time and had a distinct yellow tint.

THE UTILISATION OF PIMENTO LEAVES

Pimento or allspice is the dried, unripe berries of *Pimenta officinalis*, Lindl., a West Indian tree belonging

to the Natural Order Myrtaceæ. Pimento oil, distilled from the berries, is also an article of commerce; it is very rich in eugenol, the characteristic constituent of oil of cloves, and is used like the latter in the manufacture of the flavouring agent vanillin, and also in perfumery. The leaves of another species, *P. acris*, Kostel., yield bay oil, the production of which is an industry of some importance in the West Indies (cf. this BULLETIN, 1916, **14**, 295). The leaves of *P. officinalis* also contain a volatile oil, a sample of which was examined at the Imperial Institute in 1909 (see this BULLETIN, 1913, **11**, 438). In December 1918 a little more than 1 cwt. of the dried leaves of this species was sent from Jamaica in order to ascertain their value as a source of essential oil and for the preparation of tanning extract. The results of the examination of the leaves are given in the present article.

A so-called "wild pimento" also occurs in Jamaica. According to the Government Botanist, this is a tree which grows to a height of 40 ft., with a trunk up to 1 ft. in diameter. It occurs on the limestone in the woods of Upper Clarendon from 2,000 to 2,500 ft. altitude, and in the Dry Harbour Mountains. The tree has proved to be a new species, *Amomis jamaicensis*, Britton and Harris (Nat. Ord. Myrtaceæ). A specimen of the oil distilled in Jamaica from the leaves was forwarded for examination in June 1918, and an account of the results obtained is also included in this article.

LEAVES OF PIMENTA OFFICINALIS

1. *Essential Oil*

On steam distillation the leaves yielded 2·9 per cent. of volatile oil of pale yellowish-brown colour and pleasant odour.

The oil was found to have the following constants, which are compared with the results given by the oil obtained from the previous sample of pimento leaves from Jamaica examined at the Imperial Institute and with the recorded figures for pimento leaf oil and pimento berry oil:

	Present sample.	Previous sample.	Pimento leaf oil.[1]	Pimento berry oil.[1]
Specific gravity at 15°/15° C.	1·055	1·026	1·026 to 1·030	1·024 to 1·056
Optical rotation, α/D	− 0·55°	− 5·5°	− 4° to − 5·5°	−0°40′ to − 5°
Refractive index, n/D	1·534	—	—	1·525 to 1·535
Phenols . . . *per cent.*	89	68·6	65 to 70	65 to 80
Solubility in 70 per cent. alcohol	Soluble in 1·1 vols.	Soluble in 1·6 vols.	—	Soluble in 2 vols.

[1] *Parry, "The Chemistry of Essential Oils," vol.* i. (1918), *p.* 369.

From the above results it will be seen that the oil from the present sample of leaves is of excellent quality, containing a high percentage of phenols. The phenols isolated from the oil boiled at 252°–253° C. under 755 mm. pressure and consisted almost entirely of eugenol. The oil would be readily saleable for the manufacture of eugenol, iso-eugenol and vanillin.

The oil was submitted to firms of manufacturers who considered it of very good quality. One firm valued the oil at 14*s*. per lb., which was the price then quoted for pimento oil, but stated that this was subject to the market fluctuations of pimento berries, the usual source of the pimento oil of commerce.

Another firm expressed considerable interest in the oil and enquired whether it could be prepared and shipped so as to be saleable in the United Kingdom at about 7*s*. or 8*s*. per lb. In view of this it has been suggested by the Imperial Institute that experiments should be made in Jamaica in order to determine the price at which the oil could be remuneratively produced for export.

2. *Tanning Value of the Leaves*

On examination of the sample as a tanning material the following results were obtained, the figures being in each case expressed on the leaves as received :

		Leaves.	Liquor left in still after distillation of oil
Extractive matter (non-tannin)	*per cent.*	7·9	7·7
Tannin	*per cent.*	14·0	12·5
Tintometer readings :			
Red		9·2	11·2
Yellow		33·9	47·1

The leather produced was pale brown, firm and of fairly good texture.

It will be seen that the difference in the amount of tannin in the leaves as received and in the liquor left in the still after the distillation of the oil is only 1·5 per cent. (expressed on the original weight of leaves), but in the latter case a darker solution was obtained.

An experiment on a larger scale, using about 7 lb. of leaves and distilling with steam without the addition of water to the leaves before distillation, showed that under these conditions only a small fraction of the tannin was extracted. Large amounts of water would be required to extract the greater part of the tannin from the leaves, and it would therefore probably be best in practice not to attempt to extract the tannin in the stills but to transfer the leaves, after distillation for oil, to extraction vessels such as wooden tubs and vats, and to leach the material with hot water.

In the event of the oil being exported to the United Kingdom it may prove remunerative to manufacture a tannin extract as a by-product for local use, as, although the material contains only a moderate amount of tannin, it is capable of producing leather of good quality. The preparation of the extract for export would not be advisable unless very large quantities of leaves are to be worked, as expensive and complicated plant (including vacuum evaporators) would be needed. Extract for local use could be prepared by the simpler method of evaporation in open pans, or the waste leaves themselves could be used in tan-pits in the local tanneries.

Oil of "Wild Pimento"

As already stated, this oil was distilled from the leaves of *Amomis jamaicensis*. According to the Deputy Island Chemist the yield of oil varied, the average amount obtained from 100 lb. of leaves being 202 cc. Most of the oil came over with the first portions of the distillate, and no oil heavier than water and coming over towards the end of distillation was observed, as is the case with oil of bay.

The sample consisted of a pale yellow, mobile oil, with a pleasant odour somewhat resembling that of spike lavender oil.

The oil was submitted to chemical examination at the Imperial Institute with the following results :

Specific gravity at 15°/15° C.	0·8895
Optical rotation (α/D) at 22° C.	− 6° 0′
Acid value	2·4
Ester value, before acetylation	4·2 [1]
,, ,, after acetylation	129·4 [2]
Solubility in 70 per cent. alcohol at 15° C.	Soluble in 2·5 vols., becoming cloudy with 6 vols.

[1] *Corresponding to* 1·5 *per cent. of esters, calculated as* $C_{10}H_{17}OAc$.
[2] *Corresponding to* 39·4 *per cent. of total alcohols, calculated as* $C_{10}H_{17}OH$.

The oil shows no resemblance to the oils derived from the leaves or fruits of the ordinary pimento (*Pimenta officinalis*, Lindl.), which contain a large percentage of phenols, chiefly eugenol (see p. 299). This wild pimento oil does not contain any appreciable amount of phenols, the most important constituent being l-linalol.

A firm of essential-oil distillers stated that in their opinion the oil was of commercial value, and that in pre-war times they would have been willing to purchase it in quantities of 3,000 to 5,000 lb. at about 3*s.* 6*d.* per lb. They added that under present market conditions the oil would probably realise from 5*s.* to 6*s.* per lb. in London, and that if any is available for prompt shipment they would be prepared to buy it at about this price. From information subsequently received at the Imperial Institute from the authorities in Jamaica, it seems that there is no likelihood of the oil becoming available in commercial quantities at present, as although the trees are fairly plentiful, they are scattered about on private property and their exploitation as a source of oil would not be remunerative under present conditions.

SPECIAL ARTICLES

NOTES ON AGRICULTURE IN CYPRUS AND ITS PRODUCTS

By W. Bevan

Director of Agriculture, Cyprus

PART I

The intention of these notes is to make available to those interested in the agriculture of Cyprus some of the information scattered in various reports, leaflets and correspondence not readily accessible to the general public.

It has long been a matter of regret to the writer that the valuable stores of information collected with so much care and ability by the late Mr. Panayiotis Gennadius, formerly Director of Agriculture in Cyprus, through having been published in Greek only, have remained beyond the reach of many who might otherwise have derived benefit from a study of his works. His writings on the general agriculture of the "Near East" are voluminous and comprehensive, and show an intimate knowledge of the subject as well as of the practices and customs of agriculturists in these regions. The results of his labours are mainly embodied in his *Helleniki Georgia* and his *Phytologikon Lexicon*, both of which are works of recognised authority. During his eight years (1896–1903) spent in Cyprus Mr. Gennadius devoted himself specially to a study of the agricultural conditions and needs of the Island, and the notes and reports made by him have been, to a large extent, taken as the basis of the present Notes.

During the sixteen years since he left the Island many changes have taken place, and the more receptive and enlightened attitude of the rising generation of farmers has helped to bring about various improvements, and a greater readiness has been shown to adopt modern methods. In compiling the present Notes I have drawn freely from the articles which have appeared for many years in the *Cyprus Agricultural Journal* (formerly *Cyprus Journal*), the official publication of the Agricultural Department, and which I have edited; I have also taken advantage of


SKETCH MAP OF CYPRUS
SHOWING DISTRIBUTION OF CROPS & FORESTS
To illustrate the article "Notes on Agriculture in Cyprus & its Products" by W. Bevan, Director of Agriculture, Cyprus. Part I. Bulletin of the Imperial Institute., 1919, 17. No. 3.
C. KORMAKITI
KYRENIA
MORPHOU
NICOSIA
FAMAGUSTA
EVRYKHOU
LARNACA
PAPHOS
LIMASSOL
Vineyards
Oranges
Olives
Carobs
Cereals
Hazel Nuts
Boundary of Districts
Railway
Forests
Scale of Miles
10 5 0 10 20 30 40 50
33°
34°
35°

the very admirable and reliable information contained in the *Handbook of Cyprus*, edited by Messrs. Lukach and Jardine.

I am greatly indebted to the willing assistance of Mr. Procopios Symeonides, Inspector of Agriculture, whose thorough acquaintance with local conditions and usages has enabled him to contribute much useful and informative material. I have also to offer my acknowledgments to Messrs. M. G. Dervishian, C. Pelaghias, Z. Solomides, G. Frangos, A. Klokaris, A. Panaretos and others who have kindly supplied me with data of various kinds.

It will scarcely be necessary to add that little more than a summary of the agricultural practice and resources of the Island has here been attempted, and in no sense does it pretend to be anything more. The aim has been to give the reader a general idea of what Cypriot agriculture is and, to some extent, what it is capable of doing.

I. GENERAL

Geographical Features

The Island of Cyprus is situated in the innermost basin of the Mediterranean Sea ; about 40 miles distant from the Asia Minor coast on the north, and about 60 miles from Syria on the east, and 238 miles from Port Said to the south. It is the third largest island in the Mediterranean, ranking next to Sicily and Sardinia. The larger part of the Island is in the form of an irregular parallelogram, 100 miles long and from 30 to 60 miles broad ; while on the north the eastern extremity runs out beyond this into a peninsula 40 miles long by 5 to 6 miles broad. The total area is 3,584 sq. miles. The main topographical features are the northern and southern mountain ranges running east and west and enclosing the great plain of the Messaoria. The mountains of the northern range are of an altitude ranging from 2,000 ft. to over 3,000 ft., the highest point being Buffavento, 3,135 ft. ; those of the southern range are more lofty and culminate in Mt. Olympus, 6,406 ft. above sea-level. The rivers are nearly all mountain torrents, and are dry from about July to November or December.

The area of cultivated land is approximately 1,200,000 acres, and that of the uncultivated land 1,093,760 acres, of which about 450,000 are forest land and 320,000 are susceptible of cultivation. The Messaoria plain is the great corn-growing area.

Climate and Rainfall

There are considerable extremes of temperature in the plains. In summer it is very hot and dry with temperature ranging during June to September from 80° to 110° Fahr., while in winter slight frosts not infrequently occur. The climate is more equable, but also more humid, along the coasts. In the plains there is, during the greater part of the year, a marked variation between the day and night temperatures.

Official records show that for a period of thirty-two years up to 1915 the average rainfall for hill and plain for the whole Island approximated to 20 inches. Up to 1902 records were kept only in the six district towns, but since then there have been some fifty recording stations. The mean rainfall during the winter months for the twelve years ended 1914 was 18·55 inches. That for the whole year during the latter period was 21·18 inches.

The incidence of rainfall, apart from its volume, is of importance. It is on the rainfall of the six winter months, October to March, that the prosperity of the Island depends, and any shortage during this period cannot be balanced by heavier summer rains, which are more liable to cause harm than good, by damaging the corn lying on the threshing-floors and by causing sudden floods.

Much importance attaches to the rains in March, without which the grain crop, however ample the earlier rains may have been, will not be satisfactory, as described in a maxim which I have attempted to render in English.

> If twice in March it chance to rain,
>   In April once, a shower in May,
> In weight in gold of man and wain
>   The farmer's crops are sure to pay.
> If roads are dry at Christmas time,
>   But Epiphany finds both mud and slime,
> And at Carnival they still hold many a pool,
>   The farmer finds his barns quite full.

Administration

The Island is administered by a High Commissioner. There is an Executive Council and a Legislative Council consisting of six official members and twelve elected members, of whom three are elected by the Moslem and nine by the non-Moslem inhabitants. The Island is divided into six districts, in each of which the Executive Government is represented by a Commissioner.

Weights, Measures and Currency

Nearly everything except corn, wine, oil, carobs, cotton and wool is sold by the oke.

An oke, dry measure, equals 400 drams, or $2\frac{4}{5}$ lb.

The liquid oke is reckoned as equivalent to a quart.

Grain is measured by the kilé, regarded as equal to a bushel.

Wool, cotton and oil are sold by the litre of $2\frac{4}{5}$ okes, but commonly reckoned as $2\frac{1}{2}$ okes.

Carobs are sold by the Aleppo cantar of 180 okes. This cantar is further divided into 100 litres of 1 oke and 320 drams each.

Wine is sold by the kartos = 4 okes, the kouza = 8 okes, and the gomari = 128 okes.

1 kilé of wheat weighs 20 to 22 okes.

1 kilé of barley weighs 14 to 18 okes.

1 kilé of oats weighs 13 to 14 okes.

1 kilé of vetches weighs 23 to 24 okes.

1 sack of straw weighs about 40 okes.

1 camel-load of straw weighs about 200 okes, consisting of 2 sacks, each weighing about 100 okes.

Measures of Length

Metron or metre.

Yarda or yard.

Pic = 2 ft. or two-thirds of a yard.

Inch = English measure.

The land measure is the donum (called by the villagers "scala"), but it is very uncertain, and varies in different parts of the Island. As recognised by law, 1 donum, called

"tappoo donum," equals 60 pics = 40 yards square = 1,600 square yards, or 14,400 sq. ft.; 3·025 of these donums go to the acre. There is also a farmer's, or "reshper" donum, which is commonly used by agriculturists and is equal to about 1½ Government donums. For general purposes a legal donum is about one-third and a Cypriot farmer's donum about one-half of an acre. "Stremma" is also a synonym for the farmer's donum, or scala, although its actual measure is very much less.

Currency

£1	= 20 shillings or 180 copper piastres.
1 shilling	= 9 copper piastres.
1 cp. (copper piastre)	= 40 paras.

II. AGRICULTURAL CONDITIONS

General

Agriculture is the main industry of the Island, which is favourably situated for the markets of Egypt, Syria and Asia Minor, although the former is practically the only buyer of its perishable produce. During recent years the Cypriot agriculturist has come to realize more and more the value of the Egyptian market and a considerable trade with that country has grown up.

Land Tenure and Labour

The small farmer mostly cultivates his own land, whereas the large landowner rarely does. The metayer, or metairie, system is fairly common, and has much to recommend it when honourably carried out by both parties, but it is open to very serious abuse.

Under this system the one party, or contractor, gives the seed and often lends the cattle. A valuation of the latter is made at the time of entering into the agreement, and a re-valuation is made on termination, any depreciation being made good by the other party, or metayer. The latter finds the necessary labour and feeds the animals and pays an agreed rate for their hire. The crops, after deduction of Government tithe, are usually divided equally

between both parties, but the conditions vary according to circumstances and the nature of the crops grown.

If cultivated land be given to the partner, such land must be returned to the contractor in the same state of cultivation as received, or the contractor, at his option, may claim the return of the seed his partner received with it.

There are also a considerable number of leaseholders paying a fixed rent. The monasteries are the largest landowners, and both cultivate their own land and let out portions to the monks or to private farmers. Much land is also held by the Church, and this is frequently let out on a yearly lease, with the result that it is badly farmed and speedily worked out.

The country is rather sparsely populated by about 275,000 inhabitants, and although the cultivators are laborious when working for themselves and when free from the hands of the usurers, they are still very backward in their methods and appliances. A less conservative attitude has of late been observed, and a greater readiness has been manifested in seeking and following the advice of the Agricultural Department. There is a great amount of indebtedness among the peasantry and usurious practices abound. This undoubtedly checks progress, as few of the smaller farmers are free agents. The matter has lately been the subject of a special Commission appointed by Government. Laws have this year (1919) been passed by the Legislative Council dealing with usury and indebtedness.

Tithes and Taxation

The tithe, which forms the principal source of Government revenue, is one-tenth of the produce of the land on wheat, barley, oats, vetches, rye and favetta, measured on the threshing-floors and delivered in kind at the Government Grain Stores. Certain allowances are made to the tithe-payers for transport. In the case of carobs, which are also subject to this tax, the tithe is taken in money from exporters at the Custom House at the rate of 9 cp. (1*s.*) per cantar from the districts of Nicosia, Larnaca and Limassol, and 8 cp. per cantar from the other three districts.

There are certain export dues, in lieu of tithe, payable on the following commodities: Aniseed 33 cp., cotton 55 cp., linseed 18 cp., mavrokokko (black cummin) 7 cp., and raisins 10 cp. per 100 okes; silk cocoons $6\frac{3}{4}$ cp., wound silk 18 cp., silk manufactured by other than hand looms 18 cp. per oke.

An annual tax is levied of $3\frac{3}{4}$ cp. per head on every sheep and of 5 cp. per head on every goat one year old and upwards, and of $4\frac{1}{2}$ cp. per head on every pig over three months old.

Credit and Agricultural Societies

The spirit of co-operation has hitherto been singularly lacking, but there are signs that a change is in progress and that, with proper guidance, the cultivators will ere long come to realise the advantages of combined effort in the production and distribution of their crops.

The establishment of village co-operative Credit Societies has long been advocated, but although a law was passed in 1913 for this purpose, there has so far been little practical outcome. Co-operation in its full modern significance is not yet understood; but one or two little village co-operative banks have nevertheless been started and show encouraging results.

There are also a few small village agricultural societies springing up, which, if properly conducted, may prove the pioneers of a general movement in this direction. The existence of such societies would greatly facilitate the work of the Agricultural Department, which would be able to influence and assist farmers through their societies, whereas now it is often not possible to reach them individually.

Irrigation

The most common method of raising water is by means of primitive water-wheels or "alakatia," often described as "Persian wheels" and resembling the "sakia" of Egypt. By these the water is carried in earthenware cups attached to the rim of a large vertical wooden wheel fixed in the mouth of a well and made to revolve by a mule

or donkey by means of a horizontal wheel and beam, or by modern air-motor. Myrtle branches are mostly employed for attaching the cups to the wheels, as these are pliable and resist the action of water.

These "alakatia" were formerly made entirely of wood, but in the nineties, iron ones ("noria") were introduced from Greece, and these have become fairly general, and are gradually supplanting the older types. They have the advantage of being more durable and lighter to work. Good iron wheel wells are now locally made. Water-wheels of this description cannot be used for raising water from a depth of more than ten fathoms below the surface of the ground.

Of late years a large number of air-motors of Canadian pattern have been introduced and are found satisfactory.

There is abundant evidence in the remains of old disused Venetian wells and cisterns that in pre-Turkish times, when the country was far more densely populated than at present, a larger quantity of underground water was utilised than now. Abundant subterranean water for agricultural and gardening purposes is to be found in almost all the coast lands as well as in many parts of the interior. Such waters are either brought to the surface along subterranean channels or by means of wells, and, for the most part, have their origin in the mountain ranges, specially in the southern range, which is the rainy region of the Island.

Artesian well-boring experiments have been made in recent years in different parts of the Island, but without substantial results. In the Famagusta district large reservoirs were constructed several years ago for impounding the surplus water of the rivers of Pedias and Ialias, but these have only been very partially successful as the water is mostly lost before it reaches them.

A satisfactory solution of the water problem is of supreme importance to the Island. There are large fertile areas which every year remain fallow, but which, if capable of irrigation, would grow excellent cotton and other summer crops, thus providing a better system of rotation. Vegetable growing and fruit culture could then also be very greatly extended.

Fig. 1.—Ploughing on a Mountain Side with Native Plough

ig. 2.—Newly-prepared Beds in Experimental Gardens.

Agricultural Implements

Ploughs.—The old wooden plough of the East is still the common plough of the country (see Plate I, fig. 1). Efforts were made from 10 to 15 years ago to introduce iron ploughs by selling them through the Agricultural Department at half the cost price and even less. High-water mark was reached in 1908 when 102 of these ploughs were so sold. These were much approved of, and the further sale was then left in the hands of merchants. The demand at once fell off and since then only a few have been introduced. For a year or two a certain number of iron ploughs of Russian make were imported and sold through the Jewish settlement at Margo.

There is now a considerable demand which it may be possible to satisfy when normal conditions are resumed. There is some prejudice against English-made ploughs on the score of weight, as they are mostly heavier than those of French, Russian, Greek and American make.

Harrow.—The native harrow, "saraclo," is a wooden beam about 10 ft. long by 12 to 18 in. broad and 3 in. thick, on which the labourer stands as it is drawn over the newly sown land. It is ineffective inasmuch as it does not break the clods, but merely presses them into the ground. Iron-toothed harrows and spring-toothed harrows have been lent by the Department for demonstration purposes to different persons, and these, particularly the second kind, have found favour and are likely to be in demand for covering the sown seed. The usual method is to cover the seed with the native plough, but the European harrow is seen to do the work more effectively and with a great economy of time.

Among the more common agricultural tools of native pattern are the following (see Plate II):

Tsappa (hoe).—The wider tool, 5 in. to 6 in., is mostly for garden use; the narrow tsappa, about 3 in. wide, is for field work.

Skalistiri.—A kind of small tsappa, 2 in. wide, having two prongs 4 in. to 5 in. long at the opposite end. It is mostly used for hoeing vegetables.

Xinari (axe or hatchet).—One end of the implement

is a sort of hoe, and the other end is shaped like a mattock. Used for cleaning off weeds, shrubs, etc., from the fields; also for cutting or splitting wood.

Kouspos.—These are of two kinds. The larger is used like a tsappa, but in stony or rocky places; the smaller is the tool used by well-sinkers. It can be conveniently handled in a confined space.

Karetta or *Cart.*—This has almost entirely superseded the old Cypriot type of cart, but the latter may yet be seen very occasionally in the Karpas and possibly in the Paphos district. It is still in use in some parts of Anatolia. In its construction no iron nails are needed.

Doukani.—The common threshing-board (see under "Cereals," p. 330). This is the primitive implement handed down from classic times and generally seen throughout the East (see Plate V, fig. 2).

Thernatchin.—A wooden shovel used for winnowing grain. It is deeply serrated, or divided, into 5 or 6 triangular-shaped teeth.

Arvalin.—A corn sieve. A goat's or sheep's skin, perforated with holes, is stretched across a round wooden frame, 12 in. to 18 in. in diameter. Instead of a skin, leather thongs or gut are stretched, crosswise on the frame. Perforated tin is now sometimes employed. These sieves are used for cleaning grain after winnowing.

Arkon.—Another kind of sieve, similar to the above, but with smaller holes for sifting fine seeds, dust, etc. Mostly made of skin, but now tin is being used.

Patourin.—A similar sieve, used for still finer work.

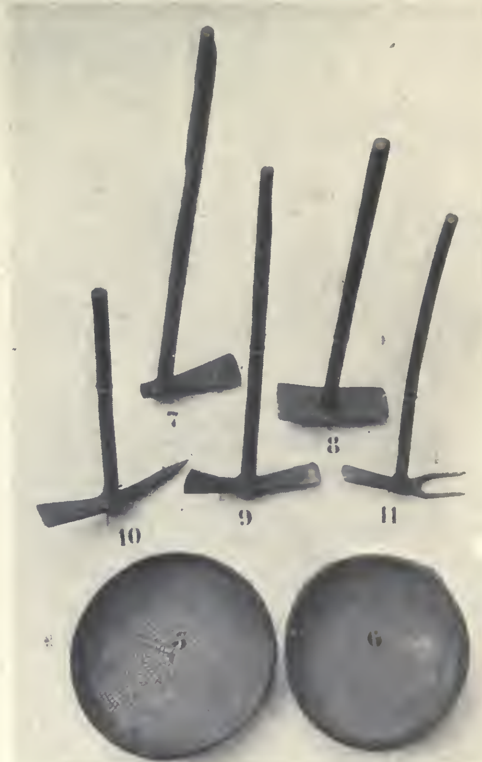
Skala.—An iron dibber, fitted with two wooden handles, used for planting vine cuttings.

Some advance has been made of late in cleaning the land, but foul land is pretty general. Squills, thistles, thorny bushes, and so forth abound; these are mostly deeply rooted, drought-resistant plants, and the labour required for uprooting them is not forthcoming.

There are a fair number of reaping machines now in use, but little care is bestowed on them, and when slightly out of order they are often put aside as useless. More enlightened ideas are now prevailing, and the abundant crops of the last few years have created a strong desire

PLATE II.

Agricultural Implements.



1, Arvalin for barley and oats. 2, Arvalin for wheat and vetches. 3, Shovel for winnowing. 4, Thernatchin. 5, Arkon. 6, Patourin. 7, Tsappa, narrow, for field use. 8, Tsappa, wide, for garden use. 9, Xinari. 10, Kouspos. 11, Skalistiri.

for more reapers and also for threshing machines, of which there are at present barely half a dozen in the Island.

The Agricultural Department

The Agricultural Department was established on a small scale in 1896, under the direction of Mr. P. Gennadius. It continued much on its original lines until 1912, when its establishment was enlarged, and the Government Farm and the Veterinary Branch were attached to the Department, and again in 1914 it underwent a further slight extension which was necessarily checked by the war. There is now a staff of inspectors, district overseers and agricultural demonstrators who are occupied in continually travelling in the country, advising and giving practical assistance to cultivators, lecturing on village wine-making, poultry-keeping, bee-keeping, on the action to be taken against various pests and so forth.

There are some eight Government Nursery Gardens in the districts from which large numbers of trees, plants and seeds are issued. A system of Model Orchards and Vineyards, newly started, is giving satisfactory results. These are intended to assist those engaged in the production of fruit and vegetables, for which an unlimited market is close at hand in Egypt.

Seventy School Gardens are in existence throughout the Island under the guidance and control of the Department. By their means many young fruit trees and other plants and seeds are annually distributed at low rates, better methods of cultivation and new kinds of vegetable and fodder plants are being made known, and the village boys are being taught something about the work on which they will later depend for their livelihood.

An Agricultural School for the sons of farmers was opened at Nicosia in 1913 under the direction of the Agricultural Department. Some twenty to twenty-five lads between sixteen and twenty years of age, both Greeks and Moslems, receive a two-year course of instruction with a view to fitting them to cultivate their own properties later. A few of the more promising students have been retained as student-labourers in the Department,

after the termination of their school course, and of these again a few have been given minor appointments in the Department. A scheme for training young Cypriots abroad, which was in abeyance during the war, makes it possible to give the more capable of these some further training in Europe in the higher branches of agriculture. It is hoped, by this means, to form a group of native experts from among whom the technical staff of the Department can be recruited.

The Government Farm, Athalassa, though somewhat ill-placed for purposes of education and demonstration, has done good work in improving the live stock of the country, as evidenced at the Animal Shows held every year. Periodical auction sales of Athalassa stock take place in the different districts.

During the three years 1915–18, there were reared at the Farm and distributed 41 cattle, 264 sheep, 8 donkeys, 332 pigs and 2 mules, besides a considerable head of poultry.

The total value of the live and dead stock was estimated on March 31, 1918, at £3,128.

For breeding purposes there were 6 stallion horses, 8 jack donkeys, 8 bulls and 7 boars in 1917–18 stationed either at Athalassa or at the stud stables which have been established in the districts. Some 30 cast army mares have been obtained free of cost from the Remount Department, Egypt, and have been lent out on contract to farmers for mule breeding.

During 1917–18 the Farm produced 169 cheeses and 1,036½ lb. of butter. In the winter of 1917–18 some 314 donums of land were under cultivation, the chief crops being barley, oats, wheat and gavetta (*Lathyrus sativus*).

The Veterinary Establishment provides for 1 Veterinary Surgeon, 2 Stock Inspectors and 1 Veterinary Compounder. There is a good deal of endemic contagious disease among the flocks and herds of the Island, mainly anthrax and goat- and sheep-pox, and the Veterinary staff is kept busy. Cattle plague is unknown in the Island.

Cattle breeding should become a paying industry when once the lesson of proper feeding and management has been learnt (hitherto sadly neglected by the Cypriot

farmer), since Egypt provides a ready and remunerative market.

Perhaps no work is of more importance than that of combating the numerous insect and other pests which every year cause heavy loss to the agricultural community. The addition of an Entomological Laboratory and the appointment of an Entomologist have enabled the Department to afford relief to many cultivators, and a small but active entomological staff are constantly engaged on various pest campaigns.

The Department possesses a small but well-equipped Chemical Laboratory under the charge of an Agricultural Chemist. In the absence of any law, the Department has, in the interests of importers and agriculturists alike, offered its services for analysing and reporting upon samples, sealing bags and giving advice as to the use of the different types, and this action has been readily availed of. This in itself, however, is not enough to check malpractices or safeguard the cultivators.

For the last four years the Department has had trial plots in which new varieties of cereals and fodder plants have been experimentally grown (see Plate I, fig. 2). The seed has been obtained from England, South Africa, India and Australia, but so far none of the varieties have been found in any marked degree superior to the native kinds. One or two varieties introduced two years ago are promising, and when fully acclimatised may be worth the attention of farmers. Experimental sowings are often made in the villages when it is desired to bring any particular crop to the notice of the agricultural classes.

The *Cyprus Agricultural Journal*, published quarterly in English, Greek and Turkish, is the official organ of the Agricultural Department.

Fungoid Diseases and Insect Pests

The Cypriot agriculturist has to contend against the attacks of many species of insects and a number of fungoid pests. Little could be done to bring these under control until, in 1914, an Entomological Branch of the Agricultural Department was established. Much valuable research

and descriptive work had been carried out by Mr. Gennadius, but no organised field work could be undertaken until the last three or four years.

A detailed description of the numerous pests cannot here be given, but the more important ones are enumerated below. Happily Cyprus is one of the few Mediterranean countries which has not been invaded by Phylloxera.

Cereals.—*Œcophora temperatella* (Limassol district only), smut and rust, hessian fly (occasionally), grain weevils (*Calandra granaria*), grain moth (*Sitotroga cerealella*).

Carobs.—*Cecidomyia ceratoniæ*, scale (*Aspidiotus ceratoniæ*) *Myelois ceratoniæ*, borer (*Cossus liniperda*), *Oidium ceratoniæ*.

Olives.—*Capnodium*, scale (*Lecanium oleæ* and *Aspidiotus oleæ*), aphis (*Psylla oleæ*), olive fly (*Dacus* sp.), *Tinea oleela* and various borers.

Citrus and other Fruit Trees.—Gummosis (Citrus and all stone fruits) ; scale (all) ; ermin moth (apples, pears and plums) ; downy plant louse, *Schizoneura lanigera* (apples) ; aphides (almond, peach, plum and apricot) ; *Tingis pyri* (pears and apples) ; codlin moth, *Carpocapsa pomonella* (apples, pears, quinces and walnuts) ; peach leaf curl, *Exoascus deformans* (peaches) ; black aphis (peaches) ; Mediterranean fruit fly, *Ceratitis capitata* (all) ; mites, *Acarus* sp. (all) ; various borers, thrips, and barkbeetle (*Scolytids*).

Vines.—*Oidium Tuckeri*, *Peronospora*, anthracnose, *Cladosporium*, root rot, *Zygæna ampelophaga*, thrips, *Cochylis*, *Lita solanella*.

Vegetables.—*Peronospora infestans* (potatoes), *Cladosporium*, *Altica*, aphides, mole crickets.

Much damage is done to carobs by the large rat, *Mus Alexandrinus*.

The large fruit-eating bat is a great pest. Hornets attack all kinds of fruits and cause much loss.

The chief cotton enemies are the cotton boll worm (*Earias insulana*), aphides and *Capnodium*.

Locusts are no longer the formidable plague they were in the eighties. They are limited almost to the Famagusta district, where they annually breed and do a certain amount of damage to early cotton and to vegetable crops. If not

Plate III.

Fig. 1.—Native Bull.

Fig. 2.—Native Ram.

vigilantly kept under control they would quickly multiply and become a serious danger.

III. LIVE STOCK

Cattle

The cattle of the country have been bred, until the last two or three years, exclusively for draught purposes. Cattle breeding as a business is unknown. Farmers, as a rule, aim only at raising a calf or two every year in order to maintain one or more yokes of oxen. Some of the draught animals are very fine (see Plate III, fig. 1, and Plate V, fig. 1). These belong mostly to the monasteries; one animal exhibited at a recent show measured over 17 hands. The race is presumably the result of many crossings with imported breeds, but has acquired a definite type. The cows are in colour and conformation not unlike Jerseys, but larger and without the udder development of that breed. The oxen have mostly a more or less pronounced hump, possibly acquired through many generations of progenitors used exclusively for draught purposes. In some of the best bulls this hump is particularly marked.

In 1912 some Devon bulls and cows were imported and a herd of this breed was started at the Government Farm, Athalassa. An impetus was thus given to breeding dairy cows, and a number of half- and three-quarter-bred cows are now to be found, which command high prices for milking purposes. The Devon bulls, however, have never come into favour among farmers for raising draught cattle.

There was a fair export of cattle to Egypt before the war, a good proportion of the animals being consigned to the Serum Institute, Cairo, as Cyprus cattle, alone among the cattle in this part of the Levant, have so far been free from plague.

The number of horned cattle in 1917 is officially given as 48,761.

The exports for the five years preceding the war were:

Year.	Number.	Value. £
1909	2,357	11,314
1910	4,240	20,218
1911	9,664	44,871
1912	5,751	34,303
1913	3,017	20,110

There can be no question that if more attention were paid to growing fodder crops, cattle breeding could be greatly increased, and a good trade with Egypt might be done.

The establishment of the Athalassa Stock Farm has had a most useful influence on the improvement of the live stock of the Island.

Beef has only lately become an article of food for the country people, and is still so only on a small scale. The townspeople, having become Europeanised to a greater degree than formerly, are now becoming beef consumers, and the high price of beef has had a stimulating effect upon breeding for the butchers. Before the British occupation the killing of an ox for eating purposes was considered by many villagers an act of sacrilege.

Sheep

Sheep rearing is an important industry in Cyprus. The sheep are of the fat-tailed species and are allied, though superior to, the Afrikander sheep. The total number of sheep in the Island in 1917 was 255,150.

They feed almost entirely by grazing, and wander, under the charge of shepherds, over considerable areas in search of food, frequently in company with goats. They are valued chiefly for their milk and meat; their wool, though of moderate quality, is small in quantity. (See also under "Dairy Products," p. 324.)

Large numbers of sheep are killed annually for local consumption, and there is a regular export to Egypt, as shown by the following pre-war figures:

Year.	Number.	Value. £	Year.	Number.	Value. £
1904	13,923	10,544	1909	976	716
1905	8,816	7,572	1910	3,905	3,064
1906	5,427	5,470	1911	18,143	12,311
1907	2,859	2,699	1912	17,611	13,731
1908	849	835	1913	7,920	6,724

Sheep-folding is practically unknown, and no crops are specially grown as food for sheep. Occasionally they may get a little rovi (vetch), rovi straw, lentil straw, favetta, pea-haulm or (in the hills) mavrachero (tares).

They suffer in years of drought, but on the whole thrive wonderfully well on very scanty pasturage.

Good work has been done of late years in the improvement of Cyprus sheep at the Government Athalassa Farm, and ewes and rams from the farm flock are much sought after by sheep-owners, many of whom are making efforts to ameliorate the breed. The question of providing suitable forage also is not being lost sight of.

Goats

The goat has been a cause of much controversy for many years and a source of discord between farmer and shepherd. Owing to the absence of farm boundaries the herds of goats (and sheep) continually trespass on the cultivated areas, and the shepherds are at little pains to restrain them when there is a chance of the animals getting a good meal. Large sums in the aggregate are paid by way of fines and damages, but the shepherds evidently find that even so it is profitable to continue such practices.

In consequence of the serious harm done every year in the State forests by these animals, a law "For the gradual exclusion of goats from the Island" was passed in 1913 and came into operation on August 1 that year.

As the subjoined table shows, the number of goats has decreased, but it is doubtful how far this is due to the law, and how far to the losses from goat-pox, which is very prevalent, and to the shipments for military purposes during the war:

Year.	Head.
1880	210,736
1890	237,475
1900	243,397
1910	276,794
1913 (when the law was passed)	242,524
1918	191,017

The goat is in many respects well suited to the Island, and provides the villager with milk, cheese, meat, boots and manure. The animals cost very little to keep—even apart from their depredations—and thrive, especially in the hills, under conditions unsuited to sheep and cattle. They are, however, great enemies to agriculture and

forestry, and if they are to be preserved in the Island, it is essential that both they and the shepherds be brought under strict control.

In Cyprus most of the goats have very short hair, which cannot be shorn. From this fact, and from the external shape of the animal, one may infer that it is either a variety of the Anatolian breed modified by local influences, or a hybrid of the Numidic and Anatolian breeds (see Plate III, fig. 2). The Anatolian goat has long and more or less thick hair, especially on the shoulders, sides and thighs, which, clipped in the spring, yields a not insignificant income for the goat-breeder (Gennadius).

The Cyprus goat gives on an average 150 drams of milk per day during a period of say 150 days, or say, 50 to 60 okes per annum.

A good proportion have kids twice a year, and many give birth to twins.

The price of a goat varies considerably in different districts, and before the war was from about 8*s*. to 20*s*. or 25*s*.

Pigs

The Paphos district and the Karpas end of the Famagusta district are specially given to pig raising; but this animal is to be found fairly well distributed all over the Island. The native pig is of inferior quality, but a noticeable improvement, not only in pig breeding but in pig rearing, has resulted from the introduction by Government of the Large Black breed from England in 1907. This breed has become well established at the Government Farm, Athalassa, and the progeny is now well spread over the Island. The improvement resulting from crossing with Government stock has been so unmistakable that there is now great competition for them at all auction sales and high prices are given. This increase in outlay on the part of farmers has led to greater care in the feeding and management. They find that well-bred pigs come more quickly to maturity, and that it pays to feed them well and not leave them to forage for themselves as formerly. Excellent pork and bacon are now procurable

Fig. 1.—Cyprus Pony.

Fig. 2.—Cyprus Donkeys.

during the winter, and it may be hoped that pig breeding in Cyprus has a good future before it.

The number of pigs counted in the spring of 1914 was 38,850, the third highest number on record. Since then, owing to the prohibition of export, breeding has been checked and the number declined, but now it appears to be again on the upward grade.

Before the war there was an average annual export of about 2,000 animals; but there is now a better local market than formerly.

Camels

Camels are still used to a fair extent, and the breed is good, but owing to the improvement in the roads and increased facilities for more rapid transport, these animals are less in demand than formerly.

Horses

The native breed of horse is best seen in the Paphos pony, which though small, about 13 hands, is remarkably strong and hardy (see Plate IV, fig. 1). It is said that some eighty years or so ago the breed was improved by the introduction of two Arab stallions from Turkey. A useful stamp of pony mare is also to be found in the Karpas. A marked improvement in the quality of the local horses took place from the importation, some years ago, of English pony stallions; and more recently a further advance has resulted from the addition to the Government stud of the two famous English thoroughbred stallions "Téméraire," by Greyleg out of Tereska by Isonomy out of Violetta by Hermit, and "Huckle-my-buff," by Isinglass out of Snip by Donovan out of Isabel (dam of St. Frusquin).

Donkeys

The Cyprian donkey at its best is a fine animal (see Plate IV, fig. 2). It is the common beast of burden of the villager, and is capable of carrying a load of from 160 to 224 lb.

A large number of donkey stallions have been exported

to India, Uganda, South Africa, Syria and Egypt from time to time, and the local breed has no doubt suffered owing to the best jacks having left the country. Although the villagers depend so much upon these animals, very little care is taken by them, either in the matter of breeding, feeding or proper management. The animals are mostly worked far too early, and underfed, and the majority are consequently undersized and of poor quality. Where good jacks are used, the progeny is generally satisfactory, and at shows and fairs some fine specimens are usually brought in. Owing to the increasing demand for jennets, the village breeder is inclined to put his she-donkey to a pony stallion rather than to a jack-donkey. The donkey mares range from 13 to 13.2 hands, with girth measurement of 58 in. to 60 in. and shank 6½ in. They have great room, and are well shaped with a straight back and good quarters.

It has been recommended that every encouragement should be given to the production of good donkeys, from which the best mares could be selected for mating with suitable pony stallions, such as the Exmoor and Welsh cob, for the breeding of jennets ; and at the same time an improvement in the jacks would naturally follow.

Jennets and Mules

"Owing to the excellence of the Cyprus donkeys and the poor class of Cyprus horses, the superiority of the 'jennet' (the result of mating the pony stallion with the donkey mare) is very patent over the 'mule' (the product of the donkey jack and the pony mare). The jennet of from 13.1 hands to 14.1 is doubtless the most paying animal that the Cyprus villager or landowner can produce, and its excellence for army or general pack purposes cannot be surpassed in any country in the world. Therefore, in my opinion, it is to this class of animal that the most encouragement in breeding should be given. To maintain the excellence of the Cyprus jennet every help should be given to the breeding of big donkeys, so that the plentiful supply of donkey mares of from 12.3 to 13.3 hands is available for mating with suitable imported pony stallions,

which should be placed by the Government at the breeders' disposal."[1]

Both jennets and mules, indiscriminately called "mularia," are largely used for transport purposes throughout the Island, and perform practically all the carting work of the country, but, as explained, the jennet is regarded as greatly the superior animal.

Poultry

The ordinary barn-door fowl is met with in Cyprus, as everywhere else. The local breed is a mixture of all the various races which have been imported by private persons for many years past. The most general types met with resemble the Leghorn and Ancona breeds.

The Island, owing to its climate and its corn production, is admirably suited to the poultry industry, and a sure and profitable market in Egypt can always be relied on. Something has been done of late years by the introduction of Wyandottes, Langshans and Orpingtons which have been bred by the Agricultural Department.

Proper poultry management among the villagers is practically unknown, and until regulations can be made enforceable by law for the control of poultry diseases and for the disposal of diseased carcases, poultry keepers will continue to suffer heavy losses and the industry will not prosper.[2] Lectures on poultry-keeping have been instituted in the districts by the Agricultural Department, and it is hoped that these may arouse some interest and lead to improvement.

Given the necessary guidance and control, the industry should have a good future before it.

Turkeys are very plentiful and, except in the hills, are seen in nearly every village. There are three varieties—the bronze, by far the most general, the white, and a dark brown kind which is not common.

Ducks and geese do well at Kythrea, but elsewhere are

[1] Report by Captain Goodchild, Remount Department, E.E.F., when visiting Cyprus in 1916 and 1917 to purchase mules and donkeys for army purposes.

[2] Legislation in this direction has been effected during the session of the Legislative Council just ended. (Law No. VII of 1919.)

little seen. At this village, however, they are largely bred.

Pigeons also are fairly abundant, and as they mostly feed on a neighbour's corn, they are considered profitable birds to keep.

Preserved Meats, etc.

A good deal of meat and fat is pickled, dried and smoked for consumption by the native population.

Hams and sausages are much eaten, the latter especially in the Karpas. Among the various kinds of preserved meats may be specially mentioned that known as "apokti." This is the salted and dried flesh of the he-goat, which, when cooked, is much appreciated by the villagers. The meat is sometimes minced, and after the addition of ground origanum leaves and spearmint, is placed in jars and slowly cooked. It is said that from 3,000 to 5,000 he-goats are annually slaughtered for making "apokti."

IV. DAIRY PRODUCE

Milk

Sheep and goats' milk is principally used for cheese and butter making. Fresh milk of any kind is not much consumed by the native population, although within the last few years the more well-to-do townspeople have taken to drinking cows' milk, when obtainable, and it is in growing demand in some country parts for invalids when prescribed by the local doctor.

The flavour of sheep and goats' milk is a good deal affected by the herbage or shrubs on which they feed, and thus varies according to locality. A characteristic odour is imparted, for instance, by the alnifolia oak (*Quercus alnifolia*) and the cistus, which are common in many parts of the Island, and the cheese and butter produced from such milk are in better demand in the local markets. The places in which this quality of milk is chiefly produced are the Paphos District, the neighbourhood of Kykko and Trooditissa in the Troödos mountains, and Akanthou to the north-east of the Island.

A considerable impetus has been given to the production and consumption of fresh cows' milk by the establishment of a herd of Devon dairy cows at the Government Farm, Athalassa. Cows of Athalassa strain fetch high prices, as much as £80 having been given recently for a cow and several others have changed hands at £50 to £60.

Cheese

The Cypriot is a great cheese eater. The most popular and commonly made cheese in Cyprus is that known as Halloumi; the next in order being the Paphos and Akanthou cheeses, and then, in imitation of the Greek cheeses, the Agrafa, Kefalotyri and Kaskaval, all of which are of a hard kind, while there is a small production of the Greek soft cheeses Fetta and Telemés.

There are no statistics as to production; the export figures in recent years as given in the official trade returns are as follows:

Year.	Quantity. *Cwts.*	Value. £
1904	5,606	8,040
1905	4,705	7,245
1906	2,511	4,238
1907	2,200	4,559
1908	2,786	5,824
1909	2,367	4,927
1910	3,345	6,564
1911	3,647	6,624
1912	3,335	7,203
1913	3,699	9,268
1914	4,582	10,132

Halloumi.—This cheese, though rather insipid, is very popular, and forms a large part of the dietary of every household. It is easy to make, needs no special appliances, and is almost entirely made by the shepherds themselves. It is made either from sheep's milk only, or, in the hills where goats are numerous, from sheep and goats' milk mixed, or in some places from goats' milk only; especially is this so in the mountains where sheep are not found. The two kinds of cheese, *i.e.* those made from sheep's milk and those from goats' milk, are easily distinguished, as the former is rather soft and crumbly, while the other is hard and separates out into flakes.

This cheese as it comes from the mould is in the form of a slab called " kefali." This is then divided into four or more pieces.

There are two kinds of halloumi : one called " mona " (single), the other " dipla " (double). The latter is most in demand. It differs from the first in being finished off by being well hand-pressed, and then doubled or folded over, salt and spearmint being sprinkled between the fold.

" Myzithra," or, as it is more commonly called, " anari," is a soft cheese produced by boiling the whey, whereby all albuminoid substances not previously coagulated are now coagulated and rise to the surface together with any pieces of curd still remaining in the whey. A good quantity of fat is also enclosed in the coagulated mass, which is placed in rush moulds or in cloths and pressed so as to squeeze out the whey. " Anari " thus made is specially known as " bastard," and is an excellent soft cheese, very popular among the European residents as well as among the native inhabitants.

A rather finer " anari " with slightly different flavour is made by adding 5 to 10 per cent. of pure milk. This added milk is known as " prosgalo."

Both kinds are dried in the sun.

From " anari " is made a kind of fat used as cooking butter, by crushing and rubbing it between the hands in warm water. A thin paste is thus formed from which a fat separates, which rises to the surface, and is then collected.

Paphos and Akanthou Cheeses.—These are prepared in much the same way as " halloumi," but are made in smaller, barrel-shaped moulds, and are steeped longer in the whey, which produces a rind and renders them tougher and less liable to crack. They are well rubbed with salt. Their characteristic flavour is doubtless due to some extent to the milk of those districts, as explained above. Owing to their small size they become very hard.

Kefalotyri.—The best cheeses of this type are made with sheep's milk, which is coagulated at its natural temperature immediately after milking. Rennet is added so as to produce coagulation within an hour. The cheeses are placed in moulds, pressed and salted. They are turned

and salted every day for a week; and this continues for two or three weeks, until the cheeses cannot absorb more salt.

Fetta.—The process for making this cheese is much the same as for Paphos cheeses, but differs in regard to temperature. It is placed in bags and hung up, or left in cheese cloths on the table to drain. It is made up in 100 or 200 dram pieces, and turned and lightly salted for three days; then placed in barrels filled with brine. This cheese ripens in a few days. It is soft, and has a sharp, pungent flavour. It is the first to come on the market. It is not consumed in Cyprus, but made entirely for the Egyptian market, where it is much liked. Being soft, it does not keep well, and should always be kept covered in brine. For these reasons it is exported in small barrels of a gross weight of 40 to 50 okes. If care is taken in this respect, if all leaky barrels are kept refilled and cool storage provided, it may be preserved for a year; but these conditions are rarely fulfilled in Cyprus.

Telemes.—This is another soft cheese, prepared in a similar manner to "fetta," but it is cut into square blocks and placed not in barrels or vats, but in tins which, when completely filled with cheese and brine, are soldered down. This cheese is also made entirely for the Egyptian market.

Kaskaval or Kaskavalli.—This is mostly made by cheese-makers who come over from Greece or Turkey during the cheese-making season.

The curd, after the whey is drained off, is called "phlongos," and it is almost always bought from the shepherds, each shepherd preparing it in his own way. It is transported in baskets, sometimes a good distance, to the cheese factory, or "kassaria," and these drawbacks, added to lack of cleanliness, are the cause of much cheese of inferior quality being produced which has no keeping properties and must be quickly consumed.

Having reached a pasty condition, the cheese is placed in reed or willow baskets and immersed in either boiling whey or clean water and stirred until the whole mass is transformed into "kossimari"; it is then cut into pieces weighing one or two okes, and moulded by hand into a globular form, leaving one slight depression called the

"omphalos" or navel. If not properly stored, this cheese soon dries and becomes rancid or tasteless.

Agrafa Cheese.—This is made entirely from sheep's milk. Coagulation should be completed in 25 to 30 minutes. The cheese remains 20 hours in the press. Salting lasts from 40 to 60 days, and the cheeses ripen in four months. If well stored, the cheese may keep for two years.

Butter

Butter making is carried on to only a limited extent in Cyprus, and with two or three exceptions is in the hands of shepherds, who use a primitive conical-shaped churn, something after the Danish pattern. Churning consists in beating up the contents of the churn with a stick, to the end of which is fixed a round wooden disc 6 to 10 in. in diameter, not unlike a piston in its action. Sheep's milk is mostly used and, with a modern churn, this will yield 9 to 12 per cent. of fresh butter. Goats' milk gives about 5 to 6 per cent. About half the above quantities may be obtained with the older, native churn.

In the Near East (Greece, Turkey, etc.) fresh butter is not used in cooking, as almost all cooked food is fried and butter containing the least water and casein cannot serve the purpose. The pure fat must therefore be extracted. Two methods are applied. The best is that of plunging the tins containing the fresh butter into hot water which heats the butter and sends the fat to the surface. It is then collected and slightly salted. This has a good flavour and keeps well.

The second method is to place the fresh butter, or the residue from the former process, into tin pans and boil until the water is evaporated, when the albuminoids solidify at the bottom of the pans. The fat which is then on the surface is ladled out. This is inferior in quality, and has a disagreeable smell imparted by the albuminoids which come in contact with the hot pan.

Xynogala or Yaourti

The former is the Greek, the latter the Turkish name for this preparation of sour milk. Unlike fresh butter, it forms,

in season, part of the diet of almost every Cypriot household. It is now made in England and sold as "Bulgarian milk" or "yaourti." It is in the form of clotted cream, but if placed in a bag of fine cloth and if the whey is left to drain off, it forms a thick paste, and has an excellent creamy flavour, and is eaten in both cases either alone or, like Devonshire cream, with stewed fruits, etc.

Trachanas

This is another favourite milk preparation, being a mixture of "yaourti" and ground wheat made into a thick paste. This is sun-dried and makes an excellent soup.

Kaimaki or Tsippa

This much resembles Devonshire clotted cream. It is the natural cream formed after boiling the milk overnight and setting it in shallow pans to cool. If the boiled milk is poured into the pans from a height, so as to make a foam, a better result is obtained.

V. CROPS AND OTHER PRODUCE OF THE LAND

Cereals

The Messaoria plain is the principal corn-producing area of the island. Wheat, barley and oats are the chief cereals grown, and they are sown more or less throughout the whole of Cyprus, nearly up to the summit of Troödos, to an altitude of about 4,500 ft. Indian corn has been cultivated for ten years or so, and is becoming more general both for green food and for seed, and rye has begun to make its appearance during the last few years. Dari is becoming more known.

The preparation of the land for cereals is as follows: About the middle of January, when the land is soaked with rain, the fallow field (*νέασμα* or *νεατός*) is broken up, and in some cases sown with a green fallow, and in March or April it is cross ploughed (*δίβολο*). If the autumn rains are early, the field is ploughed for a third time (*ανάκομμα*), after which the crop is sown; but if the rains are late, the

sowing is done on fields which have been cross ploughed only. As a rule sowing begins after the autumn rains, and may go on until January. But if rain does not come before the end of October, many sow before the rain; and in many places farmers sow regularly before, *i.e.* without waiting for the autumn rains. This sowing is called *ξερόβολα*. Lands flooded by a river or other running water are called *πότιμα* (*Handbook of Cyprus*, p. 154). The sowing is done broadcast; the drill is not used.

Often, owing to want of sufficient hands and shortness of time or other reasons, land which has been fallowed is sown without being first ploughed up. This is called *εἰς τὸ πρόσωπον*, *i.e.* on the surface, or face of the field. Again, a field which has had a corn crop is sown the next autumn without ploughing; and this is locally called "on the stubble."

It is not uncommon for the same land to be sown year after year with a corn crop, with no rotation. This is especially the case with the deep soils in the plains, known as "kambos," as contrasted with the shallow, rocky soils called "trachonas."

At the time of harvest numbers of labourers, men and women, usually arrive from Anatolia and Syria and find employment in the fields.

The threshing-floors are practically identical with those of Biblical times. They are frequently paved with flag-stones, but as often as not are merely levelled pieces of ground. On these the sheaves are opened and spread out for the threshing. The threshing-board (*δουκάνι* or *δουκάναις*) is that referred to by Virgil as *tribulum* (Georg. Bk. 1) and is merely a stout board, studded on the underside with sharp flint stones (see Plate V, fig. 2). This is drawn round and round over the spread-out sheaves by mules, donkeys or oxen, and affords a pastime to old and young during the summer months. During the process the grain is separated from the straw, and the latter is bruised and partly shredded, and it is the rooted belief of the Cypriot farmer that only in that condition will it be relished by and benefit the animals which feed on it. The straw is then gradually cleared away, and the grain is winnowed by being thrown up in the wind with wooden shovels,

Fig. 1.—Carting Corn.

Fig. 2.—Threshing Corn with Native Threshing Board.

The grain is then heaped up and left until measured by the tithe official. With the grain is also collected the sweepings of the threshing-floor, and the percentage of the foreign substances mixed with the grain varies from 5 to 15 per cent. There are a few winnowing machines and it is hoped that they will come into more general use as soon as they can be imported.

At Athalassa all cereal crops are reaped and threshed by machinery.

A good many reaping machines were imported by the Agricultural Department some years ago for resale to the farmers, and there is a very fair demand. This procedure has not been permitted for some years, and the work fell into the hands of an English merchant who has succeeded in placing a few machines every year. The country is ready to employ these and other agricultural machines, but the farmers need guidance in the choice of a machine and are reluctant to place orders through native merchants, who may not know the best types to supply and whose profits they fear to be exorbitant. If they could procure these through the medium of the Agricultural Department they would be encouraged to make considerable purchases. The loss of grain on the " aloni " alone may be gauged by the current opinion that each pair of oxen consumes, while threshing, one kilé of grain per day. Much damage is often caused by hot westerly winds at the time when the grain is just forming.

In the absence of any law to prevent the adulteration of cereals, dishonest practices are very frequent. A common method of adulteration is to mix with the grain the joints of the straw which are cut during the process of threshing and separated when winnowing. These are often sprayed with water in order to increase both bulk and weight. The moisture is absorbed by the grain, which thereby swells and is made to look bigger.

Under the Seed Corn Law of 1898 the Government make advances of seed wheat, barley, oats and vetches to cultivators under an agreement to repay in kind after harvest a quantity of grain equivalent to the amount of seed so advanced, together with an addition of one-fourth of the quantity so advanced, by way of interest.

This benefit is very generally availed of by smaller cultivators. It has not, however, been found possible for Government to keep separately the various kinds and qualities of tithe corn, from which these advances are made, and farmers frequently complain that the seed, so issued promiscuously, is unsuitable to the land, aspect, or special conditions on individual farms. Weevilled grain also is a source of trouble, and farmers obtaining such seed advances must be prepared to run risk of failure from this cause.

It is a well-known fact that cultivators often sell their seed corn so advanced them, in order to buy some other corn known to them as more suited to their land, and they are often justified, perhaps, in so doing.

The issues are made by District Commissioners to selected applicants who are believed to be unable to buy seed for cash. The average annual issues, for the last five years, have been: wheat, 38,013 kilés; barley, 31,479 kilés.

Wheat

In ancient times, when the population numbered about 1,100,000, the Island was said to be self-supporting in the matter of wheat. Taking the annual consumption of wheat per head of population at 8 bushels (Gennadius's *Report on the Agriculture of Cyprus*, Part I, p. 8) and after making an allowance for seed, the annual production would then have been about 10,000,000 bushels. From British Consular Reports it appears that in 1863 the average produce was reckoned at 640,000 bushels. The average annual production of wheat for the ten years ended 1913, as shown in Blue Book Returns, was 2,292,827 kilés. For later years the figures are:

Year.	Kilés.
1914	1,924,336
1915	1,761,501
1916	1,524,484
1917	1,782,800
1918	2,424,570

Wheat is sown at the rate of 1 kilé per donum. The average yield per donum is 6 to 10 kilés, and varies between 3 to 4 kilés on dry land in a poor year, to 16 to 20 on the

best lands in a good year. When rains are very late and spring weather is unfavourable, a farmer often fails to recover even the seed.

Much might be done to increase the yield by better methods of husbandry, by the use of improved implements for cultivating and reaping, and by the use of threshing machines. An immense quantity of grain is consumed by birds (larks, sparrows, doves, etc.), which at times literally strip the fields and continue their depredations on the threshing-floors.

Wheat is sown from October to December; a field which has had a winter crop is pastured after the harvest until January; in January and February it is broken up and cross ploughed and sown immediately after with a spring or summer crop.

The crop is cut about May–June. It is cut with a sickle (*δρεπάνι*), tied into sheaves, and carried on donkeys or small carts to the threshing-floors. The sickle is larger than the European one, and is often provided with bells ("koudounia" or "sousounaria") to frighten the snakes, and the handles are ornamented with leather tassels.

Several varieties of wheat are grown in the Island, mostly of the hard kinds, these being preferred by millers.

The following English varieties have been imported and tried during the last four years: Improved Treasure, White Stand Up, and Improved Red Fife. The two former failed, being too late in maturing; the latter is still under trial, but it is not very attractive, being a late variety, and it gives a smaller yield than the native kinds. The same remarks apply to several wheats obtained from India and South Africa and which are still under trial.

Barley

This crop is sown about the same time as wheat, if anything slightly earlier; and it is ready for the sickle three or four weeks before wheat. When the straw is short the plant is uprooted, not cut.

It is sown at the rate of 1 to 1½ kilés to the donum, and may be expected to yield from 10 to 15 kilés; but 30 kilés is not uncommon in the plains, and even much larger yields have been recorded from time to time.

There are three native varieties, viz. the common 4-row, the ordinary 6-row and the Paphos 6-row barley, also grown around Davlos in the north-east of the Island. The last-named is heavier than the two former kinds. Little success has attended the introduction by the Agricultural Department of "Prize Prolific," "Gold Thorpe" and "Chevalier," which have been experimentally grown for the last three years. They mature late and have not resisted severe drought. Their yield is small compared with native barleys, although this may improve when they are fully acclimatised.

Barley is the staple food for all kinds of animals, pigs and poultry in Cyprus, and it is often used for bread-making in years of wheat shortage.

The tithe is mainly exported to England, where it has a good name for malting purposes, especially that produced in the Paphos district. It has failed to attain the place it deserves on the English market owing to the high percentage of dirt, etc., it mostly contains.

A sample of Cyprus barley examined at the Imperial Institute in 1914 proved to be of good malting quality, and similar material if marketed in commercial quantities would be readily saleable in the United Kingdom (see Bulletin of the Imperial Institute, vol. xii. 1914, p. 552).

A sample of naked or skinless barley from Cyprus has also been reported on by the Imperial Institute. This type of barley cannot be employed for malting for ordinary brewing purposes, but it was considered that the Cyprus material might be used by distillers (who only require a partially malted barley), and in any case the sample would rank as a good class feeding barley (*ibid.* vol. xiv, 1916, p. 159).

The average annual production of barley, as shown by the Blue Book returns, for the ten years ended 1913 was 2,449,285 kilés. For later years the figures are :

Year	Kilés.
1914	1,957,944
1915	1,912,316
1916	1,953,628
1917	2,508,880
1918	3,080,710

These figures should be contrasted with British consular estimated average in the sixties of 960,000 bushels.

Oats

In Cyprus, oats are used on a far smaller scale than barley as food for cattle, and they are unknown, except to a few townsfolk, as a food for human beings.

The cultivation of this crop is restricted, partly because it ripens late and needs late rains, and partly because it sheds its ripe grain too quickly for the ordinary easy-going farmer, who frequently finds his next year's crop smothered with self-sown oats. It is also commonly held that the crop exhausts the soil.

There are two native varieties, both white. The one is grown much more than the other, called "anoyira," which, although incomparably superior, is little cultivated outside the Limassol district.

The seed is sown at the rate of 2 to 2½ kilés to the donum, and a yield of from 20 to 30 kilés is obtained. The average annual production for the ten years ended 1913, as shown by Blue Book returns, was 394,695 kilés. For later years the figures are :

Year.	Kilés.
1914	404,917
1915	378,724
1916	446,469
1917	306,010
1918	313,260

Besides "Black Tartar," which has been regularly grown at Athalassa for several years, the Agricultural Department has introduced of late years "Black Cluster," "White Cluster" and "Supreme." All these ripen late and need late rains, and they have not given any promise of success. A black variety imported from Greece some years ago has proved much superior to the two native varieties, but its cultivation is still limited.

Reports on oats from Cyprus and on oat, straw and kyko oat plant (*Avena sativa* var. *obtusata*) are given in the BULLETIN OF THE IMPERIAL INSTITUTE (vol. xv. 1917, pp. 308–10).

Rye

Rye has only lately been introduced by the Agricultural Department, but already its cultivation, though very small, is extending. The dark colour of the rye loaf creates some prejudice against it, but its value in cases of diabetes, a common complaint in Cyprus, is greatly in its favour.

The seed is sown and cultivated here in the same manner as wheat, but at the same time or even earlier than barley. It is harvested by being cut and is threshed on the threshing-floor. The straw is fed to animals, but when threshing machines become more general the long straw will become available for other purposes than cattle food, *e.g.* in the manufacture of the native saddles ("stratura"), native straw trays and native straw hats.

Rye is also grown for green food, in the same way as barley grass.

Maize (Indian Corn)

This crop was first introduced by the Agricultural Department in 1902. Its cultivation is governed by the water-supply. It is grown mostly for green food, and is met with very generally throughout the Island, being sown among the growing crops, *e.g.* louvi, sesame, cotton, etc., as a wind-break or to afford shade. There was a good demand for the grain for grinding during the war and the meal is found to be a useful ingredient in the ordinary loaf. The stems and leaves provide a welcome change of food for cattle when exhausted from threshing and during the dry season of the year. At the Government Farm at Athalassa the stems and leaves are made into ensilage.

Dari or Millet (Sorghum vulgare)

This crop is little grown, and is mostly found in the Messaria and also at Paleochori, almost exclusively in places irrigated by river floods. The grain is used for making flour and the fresh stalks are fed to cattle.

Fruits

Cyprus produces a considerable variety of fruits, the chief ones exported being raisins, pomegranates, oranges

and lemons, and grapes. There is a considerable and expanding export trade in the fruits enumerated, as shown by Blue Book returns as under :

Year.	£.	Year.	£.
1904	29,706	1909	29,890
1905	29,265	1910	52,267
1906	41,716	1911	57,393
1907	36,009	1912	59,887
1908	35,027	1913	69,097

The pomegranate of Famagusta is famous, and the annual export of this fruit alone during the five years ended 1913 averaged £14,682.

Among the mountain villages apples, pears, and plums are extensively grown ; the latter specially being in good demand in Egypt.

Apricots and kaisha trees are grown generally throughout the Island, and their fruits are particularly good and plentiful. The last-named is a delicious variety with a delicate flavour and externally somewhat resembles the nectarine. Peaches are mostly grafted on almond stocks, as these are hardy and good drought-resisters, but there are a fair number of European varieties. Almond trees abound in all parts and do extremely well if properly cultivated. Other fairly common fruit trees are the quince and loquat, or Japanese medlar.

For several years choice kinds of fruit trees have been imported from England, and many thousands of trees of different kinds throughout the Island have been grafted and are now beginning to produce fruit of excellent quality. Good work has been done by the Perapedhi Wine Association, whose garden has been a centre for the dissemination of choice grafts.

Unhappily the village growers have been very reluctant to apply proper cultivation or to carry out advice in treating their trees, which have become the hosts of all kinds of diseases and insect pests. A better spirit is now being shown in this direction.

Vines and Wines

Writing in 1896, Gennadius described the industry and perseverance of the peasants, who with most imperfect

implements, by breaking up the hard rock and building up the scanty soil, formed vineyards on the steep mountain sides, and often up to their very summits. These vineyards, he says, having been mostly planted in haste in the happy days of the demand for wines (when French vineyards were destroyed by phylloxera), were formed by the personal labour of the peasant eked out by the help of loans. Since then the wine trade has passed through critical times and prices have often been greatly depreciated. The small vine-growers, who are also for the most part wine-producers, fell on evil times and became heavily indebted. They have remained so until the last year or two, when, owing to the large demand and the high prices of wines in Egypt, they have been able to free themselves.

Gennadius regarded the cultivation of the vine in Cyprus as indisputably unprofitable, and was in favour of checking its extension, and even advocated the imposition of a special tax on new plantations. At the time he wrote there was an overproduction, and the value of wine had greatly fallen, and the revenue which Cypriot wine-makers could gain therefrom would hardly suffice to cover the expenses of its transport to the market, the annual interest on their debts, and the taxes they had to meet.

The village-made wine is usually clarified by means of gypsum. It is carried down from the mountain villages in goat-skins (askos or ashia) on pack animals, and then sold to the Limassol merchants, who ship the greater part to Egypt.

The production of wine as carried out in Cyprus leaves much to be desired. M. Mouillefert, who visited Cyprus in 1892 to report on the wine industry, says : "The vintage is often gathered too late. Insufficient care is given to the picking of the grapes and diseased, rotten, mildewy or unripe grapes are often used which detract from the quality of the wine.

"The grapes are trodden and the fermentation takes place in jars and chatties of porous earth, of a capacity of 2 or 3 hectolitres, which are tarred inside to counteract their porosity. The houses in which the fermentation takes place are of almost the same temperature as the

surrounding air, with the result that in the warmer parts of the Island fermentation at first is generally rapid or disturbed, and the temperature of the must becomes excessive. In the colder parts, on the contrary, the opposite takes place and the resulting wine is rough and sharp. The use of gypsum as a preservative is unfortunately very common. The tarring of the goat-skins and jars imparts a flavour which is very unsuited to the European taste."

M. Mouillefert made the following recommendations: "Tarred jars for fermentation should be replaced by wooden vats, or, in the warmer parts of the Island, by tuns similar to those used throughout the South of France and in Algeria. Presses less primitive than those in use should be employed since these leave in the lees a very large quantity of wine. The wine when drawn off from the lees should be kept in tuns or in small wooden casks." "In short," he says, "to speak quite plainly, no good wine destined for ordinary consumption can be obtained with jars."

Some twenty years ago an English Wine Company was established at Perapedhi and, until the war, carried on a successful trade and produced some good wines manufactured on modern lines. The factory was well equipped with up-to-date plant, and its wine of port type was especially popular. It was throughout the greater part of this time owned by the firm of W. H. Chaplin & Co., London, but since the war it has been closed down. The excellent brandy of Messrs. Hadji Pavlo & Co. has found for some time a steady market in England, and there are other well-equipped wine and spirit factories at Limassol, notably those of the Limassol Wine & Spirit Co., Ltd., of Mr. M. Michaelides and of Mr. N. Joannides.

The firm of Messrs. Hadji Pavlo & Co. has carried out since 1872 the manufacture of spirits, and for twenty-five years they have been engaged in producing their "Zanatzin" brand of wines. Their V.O. cognac and three-star brandy are both excellent.

Various liqueurs, made from local products, aniseed, kernels of apricots and other stone fruit, etc., are made by this and other firms, and sold under the name "Zucki."

The principal wines, spirits, liqueurs and other alcoholic liquors produced are :

The ordinary black wine of the country, or "krasi."

The ordinary white wine of the country, or "asprokrasi."

Commandaria.

Brandy. First and second quality sold in barrels; one-star, two-star, three-star and V.O. sold in bottles.

Mastic, sold in four qualities; Zucki, sold in two qualities.

Rum and Amer Pigon.

Alcohol. 95 C. and 36 C.

Various spirits, liqueurs and syrups: whisky, vermuth, amathus, banana, mentha, mandarini, triantaphyllo, kitro, pergamotto, vanilla, violetta, anana, benedictine.

Eau de Cologne.

Commandaria is one of the oldest and most famous sweet dessert wines. It is held indeed to have been the "nectar of the gods." In the time of the Knights Templar it acquired great fame. Existing stocks are annually added to, the original vintage having in some cases a great age, so much so that, through evaporation, the wine becomes a syrup or pulp, which imparts a bouquet to the fresh commandaria which is added to it. In making commandaria the grapes are left on the vines until over-ripe and, after picking, are spread out in the sun for further evaporation, when they undergo the usual process of wine-making. In this way a sweet wine, rich in sugar and alcohol, and having a characteristic flavour, is produced. A limited quantity only is made every year, and of this a certain quantity is exported and fetches a high price, as a speciality, in England and on the Continent.

A red mastic is made at the Kykko Monastery which has acquired local fame.

The situation at the present time is generally improved, and although Cyprus wines can never form more than an insignificant proportion of the world's supply, and could not create any special market without considerable change of system and large expenditure in advertising, they may yet, by simple improved methods, by means of co-operative storage and the application of sound elementary

principles, be able to secure a more recognised position and a remunerative, though perhaps limited, demand, at any rate for some of the special brands.

For the benefit of village producers practical lectures, with the help of special apparatus, are now being given in the wine villages during the vintage season, by officials of the Agricultural Department.

The export of wines (including commandaria) and spirits during the ten years ended 1913 were of a total value of £313,920 and £55,364 respectively. The lowest and highest figures were £20,274 in 1909 and £52,351 in 1911 for wines and £3,991 in 1906 and £8,187 in 1913 for spirits. For the last four years the exports have been :

Year.	Wines (including Commandaria). £	Spirits. £
1914	29,405	4,396
1915	38,158	5,431
1916	80,165	6,865
1917	78,451	22,173

There is an export duty on wine at the rate of 8 paras per gallon, on all spirit of 20 paras per gallon and on all vinegar of 5 paras per gallon.

Some seventeen varieties of *Vitis vinifera* have for a long time been grown in Cyprus ; the most largely cultivated being the following :

Mavro (black). The commonest variety, medium-sized bunch, with dark, large, oval-shaped grapes.

Xinisteri (white). Common variety, with medium-sized bunch, white roundish grapes, thin skin. These are suited to a rich moist soil.

Voophthalmo (ox-eye). Equally common variety. Rather small bunch, with black, round and rather small grapes. Suited to a dry, calcareous soil.

The Muscat comes next, being mostly grown at Omodhos. It is the common early muscatel of the East.

The remaining kinds are locally known as Bastardico (bastard), Maratheftico or Kraseti, Morokanali or Spourta (flabby-berried), Promari or Glycopromo (early or early-sweet), Xantho, Axanthi or Phinikoto, Kouphorrhovo or Katin-parmak, Verico, Sultana, Razaki, Corinthiaki (currant), Malaga (Alexandria Muscatel), Rhodities. Of

these, several are only to be found here and there in private gardens.

Five years ago several thousand Sultana vines were imported by the Agricultural Department from Crete, and these have now become fairly well distributed over the Island and the produce is beginning to appear in the market. These dried sultanas in 1918 sold for as much as 4*s*. per oke.

Three years ago the following varieties of table vines were imported from England by the Agricultural Department :

Black Hamburg	Lady Hastings
Alicante or Black Tokay	Royal Muscadine
Canon Hall Muscat	Muscat of Alexandria

These are now being acclimatised, and it is hoped gradually to distribute a large number of grafts.

Vine cultivation covers an area of about 140,000 donums and is in the hands of some 15,700 vine growers.

Owing to defects of planting the vines of Cyprus do not in most cases begin to bear fruit before the third or fourth year, while, if modern methods were adopted, they would bear fruit in their second year and attain their full growth in their fourth year.

What is known as the "willow-head" system of pruning has been very general, with consequently poor results. Better methods have long been inculcated and are now being more and more adopted. Manuring is but rarely practised and ploughing is confined to lightly turning the surface soil with a wooden plough, and this not every year. On the higher slopes of the mountains terracing is common and necessary.

Grape mildew (*Oidium Tuckeri*) is prevalent in nearly all the vine areas. Other diseases and pests of the vine met with are anthracnose, pourridié, *Septosporium Fuckelli*, cuscute, *Cochylis*, *Zygœna ampelophaga* and *Pyralis*. Happily the stringent regulations which for many years have been in force prohibiting the importation of any kind of living plant have resulted in keeping the Cypriot vineyards free from the scourge of phylloxera.

Sulphuring has become more general of late years,

The Government has done much to bring this about, and for fifteen years or more has imported sufficient sulphur from Sicily, which has been placed in the hands of village store-keepers and sold at a fixed price by the Agricultural Department. This has never more than exceeded the bare cost and more often has been issued at half cost and in times of distress even gratis.

The vine-owners have been stimulated by the recent high prices for wines to expend more time and money on this operation. The ignorant prejudice against the effectiveness of sulphur as a cure for grape mildew has to a great extent died out. False ideas of economy alone prevent its general use.

Fresh grapes are largely consumed locally, and considerable quantities are exported to Egypt, as shown by the following table :

Year.	Quantity. *Cwts.*	Value. £
1904	12,025	1,854
1905	8,607	1,208
1906	9,563	1,487
1907	7,399	1,161
1908	6,807	1,331
1909	7,078	1,094
1910	7,588	1,216
1911	11,597	1,865
1912	12,565	2,028
1913	10,303	1,487

The average annual export of raisins for the ten years ended 1913 was 54,007 cwts. valued at £24,190. The lowest price was 5*s.* 4*cp.* per cwt. in 1909 and the highest 11*s.* 4½*cp.* in 1911. During the war the exports have been: 1914, 16,395 cwts., £7,419; 1915, 54,189 cwts., £34,467; 1916, 34,361 cwts., £38,188; and 1917, 70,624 cwts., £90,040. The annual prices in these years were respectively 9*s.*, 12*s.* 6½*cp.*, 22*s.* 2*cp.* and 25*s.* 4½*cp.* per cwt.

Up to 1905, inclusive, by far the greatest quantity of raisins had been shipped every year to Austria; Rumania, Turkey and Egypt coming next in order. Since that date Rumania has easily taken the first place, being followed at a distance by Austria, Turkey and Egypt. Since the war the bulk has been shipped for military requirements and to France, Egypt, Malta and England

for eating and for use in confectionery, and the industry has grown.

A marked improvement has taken place in the preparation of the raisins; and specially qualified officials of the Agricultural Department every year give practical instruction on this subject in the vine villages.

Citrus Fruits

Oranges and lemons are very extensively grown in Cyprus, whilst mandarines, citrons ("kitria") and sweet limes ("glykolemonia") are also found in every part of the Island. In addition, the shaddock ('phrappa") and the bergamot orange are cultivated in the Island.

The best and most common variety of the sweet orange is the oval (sometimes round) Jaffa, grown everywhere, but specially at Famagusta, where there are numerous orange groves. Another variety of good quality is grown at Lefka. The trees of both varieties produce large, firm, thick-fleshed fruit.

Bitter oranges are largely grown from seed for stock on which the better kinds are grafted. Many thousands of these, and also of the grafted plants, are annually issued from the Government Nurseries. Much loss has been sustained from time to time through disease, and in 1899 whole orange groves at Famagusta, Lefka and Kythrea were uprooted or cut right back. With the expansion of the Agricultural Department and a small qualified staff it has become possible to bring these diseases somewhat under control, and the orange and lemon production has much increased, though gummosis and scale disease still play much havoc.

In the Varosha orange groves the trees are grown in light, sandy soil, which is banked up round the trunk. They are irrigated by means of the native alakati, or noria, or more often by air-motors, which in this locality are much in vogue.

The two most common causes of failure are the persistent planting of trees too close together and overwatering. Growers turn a deaf ear to all advice aimed at changing these two bad habits. The native agriculturist is convinced, beyond the reach of argument, that the

greater the number of trees on a given area the greater will be the profit. In a land where water is so precious the deep-rooted opinion is held that the more water a plant receives the better it will thrive, and too frequent irrigation accounts to a large extent for the widespread damage caused by gummosis. Until lately pruning was scarcely practised at all. Thanks to a system of model orchards lately instituted by the Agricultural Department, better methods are at last being introduced, and fruit-growers are able to model their practice upon the work carried out on the specimen trees, alongside their own, reserved by the Department for such demonstrations.

Lemons are largely consumed by natives with their food. The produce is of large size, thick-skinned and juicy. Until some twelve years or so ago the fruit was largely sold on the trees for shipment to Russia and Rumania, but those markets failed, owing to the prevalence in Cyprus of scale disease and partly to loss through rotting in transport. The export of oranges and lemons has of late years been confined almost entirely to Egypt.

Fig (*Ficus Carica*)

This tree thrives everywhere, and is particularly cultivated at Livadhia and Lefkara (Larnaca district), in Paphos and at the Tylliria, where the small, sweet, white variety, locally called "antelounika," is grown. There are but few true Smyrna figs, but this variety is being multiplied by cuttings and also by grafting. Other good kinds are the "sarilop" and "bardajik," of which there are a few private specimens only, and the "vardika" which is more or less common, particularly at Morphou. The Lefkara figs somewhat resemble those of Tylliria and, like the latter, mature naturally; they are considered very good and are divided into two varieties, the "malantzana" and the "kourtziatika." The figs of Ktema in Paphos are the common violet-coloured variety, but are larger, and are mostly ripened artificially.

Cyprus figs are only of moderate quality, though doubtless susceptible of improvement. They resist drought and generally yield good crops every year.

The native dried fig is much eaten, and is also used as an adulterant of, if not a substitute for, coffee, and makes a good beverage, like the well-known Austrian "feigen café." Dried figs are also made into a paste and mixed with flour to make fig pies ("sykopitæ").

The method of oiling, that is, smearing with oil the orifice on the top of the fig while still unripe, is applied to those varieties which ripen slowly. It is these varieties which are especially grown in Cyprus. The fruit so treated is rather tasteless and insipid, but as it comes early to market it fetches a good price. The reason for hastening the ripening process by oiling is that the fruit may become ready for picking before sparrows and hornets get it, as they would otherwise do at that season. The later crop is more or less immune from their attacks, as ripe corn is then abundant in the field or on the threshing-floor.

Figs first appear on the market in May. This early fruit is called "magiles" (possibly from Maios-gilia = May production). The fruit is produced on the wood of the preceding year, from a bud which has remained dormant. The next crop appears about mid-July, and then the fruit is called by its proper name "syka."

Cherries

The principal and almost the only cherry-growing village in the Island is Pedoulas, in the Marathassa valley. This village is about 3,600 ft. above the sea-level. The trees at that village do remarkably well, and they bring in a good revenue. They are mostly wild trees which have been grafted; but there are also a small number which have been raised from imported Malaheb seed. From time to time good kinds of young grafted cherry trees have been imported from England by the Agricultural Department and grafts from these have been freely supplied to the village.

There are two native varieties, one ("kerasi") which is almost exclusively grown at Pedoulas, the other ("vysino") which is found fairly well distributed over the Island. The former is pale yellow and pink, the latter is slightly smaller and less sweet and of a darkish-red colour,

and is used mostly in making jam and preserves, while the "kerasi" is more for table purposes.

More grafted trees are now coming into bearing and "White-hearts" are now sold in the bazaar at about 12 cps. per oke. "Black-hearts" are also beginning to make an appearance.

Efforts are being made to introduce the cherry tree to other hill villages, and there seems no reason why its cultivation should not become general in the higher parts of the Island. This fruit travels well and a fine market awaits it in Egypt.

Owing to the prohibition of fruit exports during the war, a small industry has grown up for drying the "kerasi."

Banana

The local name of the banana is Sykiton Adam (Adam's fig), from the belief that Adam made an apron of the leaves.

There is some hope that the cultivation of this delicious fruit may become more taken up in Cyprus than has hitherto been thought possible. Paphos has for several years had the reputation of possessing fruit-yielding trees of good quality. Offshoots from some of these have been transplanted to Larnaca, and there are now several gardens in which a fair quantity of fruit ripens each year. At Kyrenia and Lapithos there are also a good number of trees. The fruit is of a different variety from that of Paphos and Larnaca, the shape being longitudinally angular, whereas the latter kind is longitudinally round and larger.

Five years ago the Agricultural Department obtained some special varieties from Zanzibar. These are now beginning to yield fruit, and offshoots are being distributed in the Island.

Azarol Hawthorn

This hawthorn (*Cratœgus Azarolus*), known locally as "mosphilia," grows wild scattered about over the country. The fruit makes an excellent jelly. The tree is an excellent stock on which to graft the pear tree.

In the higher regions another species, *C. monogyna*, is found.

Melons

The western end of the Messaoria plain is noted for its water-melons and sweet-melons. These are grown in "postania," a corruption of the Persian word "bustan," a garden. They are cultivated only on irrigable land. At Asha, where, perhaps, the best fruits are grown, the land is flooded by the river and no later watering, as a rule, takes place. Through a well-grounded fear of theft, the grower and his family live in their "postania" during the season of marketing. Reed shelters are erected, and the rolled-up beds and bedding with their white coverlets present a strange appearance. There is always a big local demand and a good yield is generally obtained from these "postania." High prices are paid for suitable melon-land.

The local names for the water-melons are "karpousia" or "paticha," and for the sweet-melons "piponia" or "tamboures."

The cultivation of this fruit is general throughout the Island.

Date Palm

This tree grows promiscuously throughout the plains, produced mostly by accidental seeding. Very little actual sowing takes place. The best groves are round about Nicosia.

The trunk-wood, being very hard and fibrous, is used in the construction of the old type of waterwheel ("alakati") and for beams in houses. It is also utilised as fuel in Turkish baths as it burns slowly and gives out great heat. Palm leaves are in demand for making various native baskets, specially the "zimpilia" for holding seed when sowing broadcast. Hats are made from them in a few villages.

The native varieties of date palm are not of high quality. They are: "Baltchik," the fruit of which ripens on the tree; "Phountouk" (hazelnut); "Kourmouzou" (red); and "Saraih" (yellow). The last three are artificially ripened when picked, by spraying them with a mixture of syrup and vinegar. The "Baltchik"

produces fruits suitable for fresh consumption. The "Phountouk" is somewhat inferior. The other two have large fruits which are specially suited for preserving.

Two years ago the Agricultural Department imported from Sudan the following varieties: "Condeila," "Bertamouta" and "Barakawi." They suffered much on the journey and it is doubtful if more than two or three specimens will survive.

As a rule dates ripen well in Cyprus; gathering takes place from October to December. The clusters must generally be covered with sacking to protect them from birds.

Nuts

Hazelnuts and Cobnuts or Filberts

These nuts are collectively known in commerce as "small nuts." They are all, however, the produce of a species of *Corylus*, the different kinds being distinguished by trade names according to their country of origin (see an article on "Sources of Supply of Hazelnuts" in BULLETIN OF THE IMPERIAL INSTITUTE, vol. xiv. 1916, pp. 261–7).

In Cyprus these are grown almost exclusively around a well-defined group of villages of the Pitsillia, notably Alona, Palæchori, Askas, Platanistassa, Phterikoudi, Livadhia, Agros, Alithinou, Saranti, Polystipos. In this locality the plantations are thickly grown and good yields are obtained. It is doubtful whether there are other parts of the Island equally well suited to this tree.

Hazelnuts, besides their use for dessert purposes and in the preparation of various nut foods, are employed largely as a cheap substitute for almonds, and in years when the latter are scarce, hazelnuts are in especially good demand.

The Cyprus nuts are outwardly of good size and appearance and are very attractive in the English market, but unfortunately they are usually picked before reaching full maturity, and consequently the kernels are frequently small and soon become rancid. Being gathered when unripe they lose greatly in weight, which means loss of

money to the exporters. The flavour is also impaired by premature picking and on this account Cyprus nuts compare unfavourably in this respect with those from Spain, and Trebizond and other parts on the Black Sea, with which they have to compete. If growers would pay more attention to this point, Cyprus hazelnuts would, owing to their size, hold a much better place than they do in the English market.

The export of hazelnuts is not separately recorded, but the annual average production is stated to be approximately 120,000 okes.

Walnuts

Some fine specimens of walnut trees are to be seen in the Marathassa valley and in the neighbourhood of Palæochori, and near mountain streams in several places among the slopes of the hills. These yield excellent fruit and are profitable to their owners, but unfortunately many trees have succumbed to the attacks of the Codlin moth. Special action has been taken during the last two years to deal with this pest. There has been a marked increase of late in the planting of young walnut trees.

Almonds

The cultivation of this tree has greatly extended of late. Its drought-resisting properties enable it to withstand the climate of the plains and on the level slopes of both ranges it grows well. There are several large plantations, notably at Psevdhas, Larnaca district, where the famous Jordan variety is found, and as the tree seems indifferent to soil, and thrives particularly well on the limestone which is so general throughout the Island, it may be hoped that it will be greatly multiplied. Both the soft- and the hard-shelled varieties are grown. Much good work has lately been done in School Gardens, under expert advice, in germinating the seed in damp sand. The villagers, finding the seedlings already to hand for planting, have been induced to plant them out.

Almonds are used as stocks on which to graft peaches, kaishas, apricots and plums (" mirabelles ").

Spanish Chestnut

Some years ago good numbers of the edible chestnut were raised at Pedoulas by the Agricultural Department and distributed to villagers for growing in the hills. It is feared that the greater part of these trees, through want of attention, unsuitability of soil or climate, lack of moisture, and especially damage by goats, have been lost, but some remain and well-grown young trees may be found in certain localities and in moderate numbers among the mountains. As soon as adequate protection from goats can be given, this tree might be well worth more extensive cultivation. It prospers well when properly cared for, but will not thrive in soils containing more than about 3 per cent. of lime or at an elevation below about 1,000 ft.

The tree has been propagated almost entirely from seed, which must be as fresh as possible. No doubt one reason for the lack of interest hitherto shown in this tree by villagers is that it does not begin to fruit, as a rule, until about its twentieth year.

Pistacia spp.

Several species of *Pistacia* occur in Cyprus, and although they yield products of different kinds, it will be convenient to deal with them together in the present section.

The pistachio nut (*Pistacia vera*), locally called "Aleppo pistachio," is a native of Persia and Arabia and it was thought, until a few years ago, that it would not thrive in Cyprus. That is, however, a fallacy, which is rather confirmed by the fact that the *P. Terebinthus* and the *P. Lentiscus* are indigenous to the Island. It is considered that the best method of cultivation is to bud *P. vera* on *P. Terebinthus*. Though they grow more slowly, these budded trees are more robust and better resist drought, cold and moisture. The trees should yield fruit in five years from the time of grafting. A fair number of these trees have now been distributed from the Government Nursery Gardens.

This tree provides the pistachio nuts which are now imported from Syria and Chios.

Male trees do not usually flower at the same time as female; consequently there has been difficulty in getting fruit with seeds, and recourse must in that case be had to artificial fertilisation.

The Palestine or turpentine tree (*P. palæstina*), local name "trémithos," grows in certain parts of the Island, but is seen at its best in the Paphos district, especially in and around the town of Ktima. The fruit is eaten fresh or salted and dried. It yields 10 to 15 per cent. of edible oil which has a certain local demand. A medium-sized tree may produce up to 60 to 80 okes of fruit. After crushing and expression, the residue together with the seed is found to be a good food for pigs. A small consignment of both the dried and salted fruit and of the residue was sold in Egypt in 1916 and realised 5 to 6 cp. per oke for the former, and 3*s*. to 4*s*. per kilé for the latter.

By making incisions in the trunks of both the male and the female trees a gum or turpentine known as "Paphos tar" is obtained, which fetches as much as 8*s*. to 10*s*. per oke. It is used locally for chewing.

This is one of the largest trees in the Island and is of handsome shape. It is deciduous and some fine specimens are met with.

Pistacia Lentiscus, locally known as shinia, or shinia bush, abounds all along the coasts of the Island. From the seeds of this shrub an oil is expressed which is used for culinary purposes, particularly for frying fish. The oil is also in good local demand for soap making, and a very fair soap is produced, especially at Akanthou, in which the oil is the chief ingredient.

The leaves of this shrub are largely used for tanning purposes and were at one time regularly exported to England, though in small quantities. The principal market for shinia leaves is Palermo. They are employed to no small extent for the adulteration of sumach, for which Palermo is also the leading market. Shinia leaves were also in demand at Lyons as a dyeing material for silk stuffs.

There are also a few specimens of a variety of *P. Lentiscus* (mastic tree) from which in the Island of Chios

the famous Chios mastic is obtained by incisions made in the trunks of the male stocks.

The terebinth tree (*P. Terebinthus*), locally called "tremithia," is a bush very widely grown throughout the higher regions. It is used as a stock on which to graft *P. vera*. The berries are used for extraction of oil which has a value for culinary purposes. They are also made into a cake called "tremithopites." The berries are much smaller than those of the *P. palæstina*.

Vegetables

The cultivation of vegetables has considerably extended of late. Good market gardens have existed in and around the principal towns for many years, but more attention is now being paid to this industry in the villages, wherever water is available, and a considerable amount of skill is shown in production.

Among the best and most generally grown vegetables are spinach, cauliflowers, cabbages, egg-plants, lady's fingers, leeks, artichokes, broad beans (also grown as a field crop), radishes, celery, beet-root, pumpkins, marrows, cucumbers, lettuces, tomatoes, lentils, kohl-rabi ("kouloumbra"), kidney beans ("phasoulia"), peas, kolokas, onions and potatoes.

There is a considerable demand in Egypt for fresh vegetables, and to meet this the land around the "ports" of Famagusta, Larnaca and Limassol has been for some years specially devoted to their cultivation. In the mountain valleys a continuous series of small vegetable gardens may be seen flanking the sides of the river-banks. The exports of vegetables to Egypt in recent years are given in the following table :

Year.	Onions.	Beans and Peas.	Other Vegetables.
	Cwts.	*Cwts.*	*Cwts.*
1909	6,664	1,729	49
1910	3,807	858	60
1911	5,512	2,346	122
1912	3,659	2,583	135
1913	2,854	1,670	32

Beans and Peas

Beans are grown for market mainly at Marathassa and Pitsillia and generally in the higher regions, but only to a small extent in the plains.

Before the war there was a comparatively large importation of beans from Anatolia. This having stopped, local prices rose and stimulated production in the Island.

The Cypriot is a lover of dried vegetables, and there might well be an extension in the cultivation of beans, similar to that which has lately taken place in the case of green peas. Except in one or two places, these were not sown by the villagers until about four years ago, but so valuable have they been found, especially in recent years of scarcity and high cost of other foodstuffs, that now whole districts are being devoted to their cultivation.

The French or kidney bean (*Phaseolus vulgaris*) is locally known under the general term " louvia." This name is applied both to *Phaseolus vulgaris* and to *Dolichos melanophthalmus* (*Vigna Catjang* var. *sinensis*). To distinguish the two kinds the Cypriot describes the *P. vulgaris* as " louvia gliastra " (*i.e.* lustrous, owing to its shiny appearance), or " louvia peratica " (*i.e.* foreign), as *D. melanophthalmus* was introduced and had become acclimatised some time before. Gennadius, however, describes the " louvia peratica " as *Dolichos Lablab* or lablab bean.

Both the dwarf (" koutsoulia ") and the climbing (" makrya " or " anarichomena ") varieties of *P. vulgaris* are grown. There are two white kinds, the large (" adra ") and the small (" psintra ").

Beans of various colours are grown here and there, and one spotted variety (" patsaloudhia ") merits greater attention than it receives at present, both on account of its greater productiveness and for its excellent flavour. Two of these are stringless, but a drawback to them is that they discolour the water in which they are boiled.

There are several newly imported kinds which are privately grown, and these are gradually coming into the local markets.

The lubia or cow-pea (*Dolichos melanophthalmus* =

Vigna Catjang var. *sinensis*), being a good drought-resister, is grown more or less throughout the Island. It is frequently sown in mixed crop with cotton, sesame, Indian corn, etc.

Two kinds are cultivated--the larger, " lubia melissomatia " (having the eye like a bee), and the smaller, " lubia mavromatoudhia " (dark-eyed).

The dried pods of *Phaseolus* and *Dolichos* are fed to animals and are also used for stuffing mattresses.

The broad bean (*Vicia Faba*) has been grown for some years on irrigated land in the plains, where it takes a recognised place in the rotation. Its cultivation is now spreading to the higher parts.

The soy bean was introduced a few years ago by the Agricultural Department, but has failed hitherto to attract attention. Villagers find it requires different cooking from what they are accustomed to, and local dealers are not yet prepared to deal in it. It has been found resistant to disease, and further efforts are being made to bring it into popular favour.

The Ochrus vetch (*Lathyrus Ochrus*), locally known as " louvana," is a fairly common spring crop, being grown for the sake of the seed which provides a favourite Cypriot dish. The leaves are also used as a salad. This crop is sown in the plains in January, but in the Karpas and some other parts it is sown in the autumn.

Chick-peas (*Cicer arietinum*), locally called " revithia," grow well and are cultivated to a moderate extent. Samples examined at the Imperial Institute proved to be of normal composition. Two firms of produce brokers in London stated that if quantities of about 5 tons at a time could be delivered in England in as good a condition as the sample they could be sold for human consumption and would be worth (1917) £20 to £24 per ton c.i.f., United Kingdom ports. If of inferior quality to the sample they would be fit only for cattle food and fetch considerably less (see BULLETIN OF THE IMPERIAL INSTITUTE, vol. xv. 1917, p. 307).

Chick-peas when roasted are locally called " koudames " and are eaten in the same way as ground-nuts, which they much resemble in flavour. They are little, if at all, used in Cyprus as a cattle food.

Potatoes

The potato-growing industry in Cyprus has developed considerably in recent years, as will be seen from the subjoined table of exports:

Year.	Quantity. *Tons.*	Value. £
1909	12,586	3,105
1910	14,983	3,839
1911	36,271	8,472
1912	45,336	10,348
1913	31,310	7,003
1914	54,203	11,741
1915	82,304	28,513
1916	136,027	74,632
1917	224,453	101,120

These figures, however, are a very inadequate indication of the actual increase of production, inasmuch as the local consumption of this vegetable before the war was confined almost entirely to the well-to-do residents in the towns, whereas now it is rapidly becoming a staple food of the people. This unascertainable but large local consumption must be added to the latest export returns in order to arrive at an estimate of present production.

The most favoured variety was at first, and with many growers still is, what is known as the French potato, the original seed having been brought from France. Irish potatoes (locally called "pittakoura") have now largely displaced these, partly, no doubt, on account of the greater facility of obtaining the latter seed during the war.

A native variety of potato, believed to have been imported by Syrian Arabs in the sixteenth century, is still grown on a small scale in the Marathassa valley. This potato has deep-set eyes and a luxuriant growth above ground and possesses a characteristic sweet taste.

Great progress has been made within the last few years in the matter of cultivation, and the old practice of planting broadcast on the flat has given way to ridge planting at proper distances apart. The practice formerly was to drop the potatoes into the plough furrow. These were covered over by the return plough; every third furrow was sown.

The Egyptian demand and the purchases made for military purposes have greatly stimulated production.

The good prices obtained have led, particularly in the Famagusta district and in what are called the "red earth" villages, to much activity and no small outlay in the matter of water-supply and distribution, and in the use of chemical manures.

The custom has grown up for importers to send their seed potatoes for planting in the higher parts of the Island. The produce therefrom is exchanged with growers in the plains, who send up their plain-grown tubers as seed to the cultivators in the hills. Merchants often stipulate with the hill-growers that they shall have their crop at an agreed, and generally a fairly high, figure. In this manner degeneration of the seed has been retarded; but owing to the difficulty of obtaining seed from outside during the war a certain amount of degeneration has taken place.

Only one crop can be grown in the hills during the year, but in the plains two crops are obtained. The one is planted in January and is dug in May–June; the other is planted in July and dug in November. It is found that the tubers lifted in the summer suffer greatly from the heat, and heavy losses occur from rot, whether the tubers remain in the ground or if they are dug and stored; and it is a question whether, when these losses are taken into account, the summer crop is really profitable.

The average yield is sometimes put at 2,000 okes per donum, but 1,600 okes, or 2 tons, is probably a more accurate figure.

Kolokas (*Colocasia antiquorum*)

This is a favourite food of the villager, but can only be grown where there is an ample water-supply and on heavy land that holds the water. It is an exhausting crop. The root only is eaten. It is sown in March–April and dug about October–November.

Onions

These are generally grown, especially in the Paphos district; Famagusta and Limassol following in the order named. The Paphos onions are supposed to have particularly good keeping qualities. Both round ("strongyla")

and long varieties (" tolmalikia ") are grown; the latter have less fleshy scales than the former.

Onions are grown either in irrigated gardens or in " livadhia," or low-lying lands which retain their moisture, no irrigation being needed. They are propagated by means of " konari " or bulblets. Lapithos in the Kyrenia district makes a speciality of producing these from seed and supplying them to the whole Island, although onions are grown for market only on a limited scale in that area. The method is to plant out the full-grown onions (locally called " mammes ") and leave them to ripen their seed. The seed is sown in February–March, at the rate of 20–25 okes per donum, from which some 3,000 okes of " konari " are raised. These are then sold for planting out in October–November–December at the rate of 40–50 okes per donum.

Onions are grown either in rows or broadcast. The native variety has the outer scales of a reddish colour, but these have largely given way to superior imported kinds.

THE WATER SUPPLY OF EGYPT IN ITS RELATION TO AGRICULTURE

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In a recent article in this Bulletin (1919, **17**, 195) it has already been shown to what extent it is possible to expand the cultivated area in Egypt, and incidentally increase the cotton-producing lands. The method suggested involves, (1) the cultural renovation of existing cultivated lands by perfected water supply and drainage; (2) the conversion of the basins into perennially watered areas; (3) the inclusion of new but uncultivated lands by the extension of the existing canal system; and (4) the reclamation of the large shallow lake areas on the northern seaboard.

Taking all the above into consideration, it must be borne in mind that the completion of such a work could hardly be carried out under fifty years, and would involve the construction of reservoirs capable of controlling the whole annual volume of the river for distribution in accordance with the periodic demands of agriculture. The order of

procedure has been indicated and the first part of the proposal corresponds to the work which has been already partly carried out. The remaining chief matters that have not as yet been placed on a basis for discussion are, the probable quantity of water available from the Nile, and an estimation of the irrigation requirements for the various crops to be grown. Calculations are now given for the first time showing the water used in cultivating the existing areas in the country in accordance with the various crops grown : such calculations being used as a basis for estimating what the ultimate water requirements would be when the proposed extensions and conversions are completed.[1]

Although it is upon the Nile that everything in Egypt and the northern parts of the Sudan is dependent, the volume of the river has usually been looked upon as so adequate for the provision of all the water required by the cultivated tracts, that little attention has been given to its annual fluctuation. Much consideration has been accorded, however, to the accurate computation of the water passing downstream during the summer months, at which particular time the water supply, unaided by the flood water stored from the previous season, would certainly not be adequate for Egypt's present crops. Care has therefore been exercised to retain as much of the flood water as possible before the river runs low, and for this purpose the Aswan reservoir has been constructed. Gigantic although this work is, rather more than one-half of the annual volume of the Nile is in a normal year allowed to flow out to sea, without having served any useful purpose in agriculture. In order, however, to make the expansion of cultivated areas to the extent proposed, other reservoirs would have to be constructed to conserve all the water at present wasted ; the ultimate aim being, the establishment of a condition in which no Nile water reached the sea until it had served the purpose

[1] As will be shown later, the calculations made in this manner, for determining the theoretical water requirements of the existing perennial areas, give a total considerably less than that of the volume of water said by the Irrigation Department to enter the canals. An adjustment is made in order to conform with the latter, whose difference is to a great, though indeterminable, extent due to influences bearing on the employment and dissipation of water carried by canals, by means other than those of crop irrigation.

of irrigation and had also deposited its valuable fertilising matter upon the land.

Before entering upon the question of the consumption of water by the various crops grown in Egypt at the present time, and upon this basis making a computation of the probable future needs of the country, it is expedient to examine the available figures indicating the annual volume of the Nile. It should be pointed out, perhaps, that an accurate calculation of the available water is handicapped by the impossibility of determining the losses and gains due to infiltration, evaporation, seepage, and recurring uses of the same water. Reliance has, therefore, to be placed upon the charts showing the amount of water entering Egypt at Wady Halfa annually for nearly thirty years, and upon the rough estimates, supplied by the Irrigation Department, of the mean discharge downstream of Aswan, and the amounts entering canals, etc.

In a paper read by Mr. Keeling, lately Director of the Physical Service in Egypt, at the Third International Congress of Tropical Agriculture held at the Imperial Institute in 1914, a chart was given showing the curves of the water volume passing Wady Halfa throughout the year 1913 (the lowest flood on record for over a hundred years), compared with the mean for the twenty-four years for which records have been accepted. The charts represent the discharge in cubic metres per second, and it is interesting to note here, in order to show the fluctuations, that the lowest point in the curve of the mean referred to was about 600–650 cubic metres per second, reached during the month of May, while the highest point was attained at the end of August, when 9,100 cubic metres per second represented the discharge of water. On the other hand, the lowest point attained in the abnormally low year of 1913 was about 500-600 cubic metres per second recorded in the month of May, the highest point being only 5,500 cubic metres per second in the first week in September.

By measuring off the two curves mentioned, we find that the mean annual discharge of the Nile passing Wady Halfa for the twenty-four years (1890–1913) was 94 milliards m^3 (94,000,000,000 cubic metres), whilst for the year bearing

the lowest recorded flood, namely 1913, the corresponding figure was 55 milliards m^3.

The occurrence of such a great difference between the minimum and the mean annual discharge of the Nile would appear to make the behaviour of the river in any one year a matter of such uncertainty that it might be risking future disaster to construct schemes for cultivation of a greatly increased area. The danger, however, is more apparent than real, inasmuch as it is minimised to a great extent by the fact that, by means of a series of reservoirs, the water of more than one year would be capable of being drawn upon, and by careful manipulation it should not be a difficult matter to keep the available supply up to the mean average. To a partial degree this is what actually occurred in respect to the year 1913. Thanks to the previous year's flood water held up in the Aswan reservoir, what would undoubtedly have been a famine year of great severity in times previous to the construction of the reservoir, resulted only in a shortage of about 200,000 acres of rice (part of which area was planted with cotton instead) and the diminution of about 250,000 acres of basin cultivation; or say, altogether, a deficit of about 7 per cent. only in the cultivated area of Egypt, for the period of one crop.

A rough estimate made by the Irrigation Department of the mean annual discharge of water downstream of Aswan has been supplemented by an estimate by the same service of the distribution of the water under the different heads of employment. The figures given are as follows:

	Milliards m^3.
Mean annual discharge downstream of Aswan	90
Perennial area supplied by canals and pumps on the Nile:	
In Lower Egypt	22
In Upper Egypt	8
Basin areas in Upper Egypt	8½
Total	38½
Deduct water finding its way back to the river	4
Estimated mean annual consumption of Egypt	34½
Amount left to reach the sea, unused by the land	55½
Total	90

It will be seen that the Irrigation Department's figure of discharge at Aswan of 90 milliards m^3 compares reasonably closely with the average volume passing Wady Halfa given before as 94 milliards m^3. Although it is difficult to see how as much as 4 milliards m^3 is dissipated between Wady Halfa and Aswan, for the purpose of this discussion it is better to assume that the lower figure represents the average available water supply to Egypt in one year. It will presently be shown that this amount, if all controlled, is more than ample to provide for the expansion of the agricultural area in Egypt in the manner previously referred to. Although it would perhaps be a presumption to suggest the technical means of attaining this condition, it seems apparent that the scheme should include the proper regulation of the tributaries of the White Nile, chiefly the Bahr-el-Jebel, which at the present time annually wastes its surplus water by overflowing a wide area before joining the main stream. In this manner, it is true, it acts somewhat as a natural reservoir, but an enormous loss must be continually occurring owing to the evaporation from the great expanse of surface.

According to the Irrigation Department's estimate of the mean annual water requirements (under the existing conditions and extent of the perennially canalised, as distinct from the basin, cultivation), Lower Egypt requires 22 milliards and Upper Egypt 8 milliards cubic metres of water per annum. These figures, it is understood, were arrived at by making an estimation for the amount of water passing into the various perennial canals and adding to it another for the capacity of the pumps on the river banks. As, however, the water in the canals is used up in other ways and for purposes other than that of irrigation, it is necessary to consider the relative importance of these. Some of them, such as the supply of towns, villages and machinery, would not take an important quantity, but others, such as evaporation and seepage, might account for a large share.

From the purely agricultural standpoint of the amount of water required for the crops grown in Egypt in one year, the following extracts are given here from a long series of calculations made by myself. These are based on the

acreage of each crop given according to the tables appearing in the *Annuaire Statistique de l'Égypte*, multiplied by a figure representing the total volume of water, found by investigation to be applied to each kind of crop,[1] but adjusted according to the variety (involving a shorter or longer period of growth), and according to the locality (different quantities of water being necessary in accordance with the variations of the character of the soil, the elevation of the land and the climatic conditions). Taking all these points into consideration and making an adjustment for a very important omission, mentioned below, which has been annually repeated in the Government Statistical publications for as long as they have existed, the figures arrived at give the theoretical annual consumption of water for the perennial crops. The chief of these latter may be mentioned in their seasons as follows :

Winter crops	*Summer crops*	*Autumn crops*
Wheat	Cotton	Rice
Barley	Rice	Maize
Beans	Sugar [3]	Millet
Permanent clover	Summer maize	
Catch-crop clover [1]	Millet	
Onions	Various [2]	
Potatoes		
Various [2]		

[1] *This crop is entirely omitted in the "Annuaire Statistique" and has perforce to be estimated in relation to the areas of the crops it precedes. For this purpose five-sevenths of the subsequent cotton and rice areas are taken as a rough equivalent.*

[2] *Including permanent plantations—vineyards, orchards and all minor crops.*

[3] *Sugar, though occupying the land for two years, is reckoned as a summer crop.*

The entire omission of the clover (*bersim*) catch-crop from the Government Statistical records of areas is very important. This crop, which is usually sown in a standing crop of maize, cotton or in rice stubble in October, nearly always precedes cotton or rice in the following year and occupies approximately 1,100,000 to 1,300,000 feddans (Egyptian acres) annually for a period of three to four months. The system employed of computing the crop areas once in the year from the returns sent in by the native tax collectors has been the cause of this omission. These returns are made when the cotton and rice have been

[1] Some of the results have been checked by Venturimeter records.

planted and the preceding clover crop is forgotten. Only the areas that carry clover as a full crop, and which are usually followed by a short fallow before maize, appear in the area returns. Other unfortunate complications have arisen in connection with the maize and millet areas, but need not be referred to here as they do not influence the water requirements. The remedy lies in the computation of areas in each of the three seasons. This might present a little difficulty at the start, but would soon assume a position of general routine, and supply information of great value.

After making the adjustments just referred to, it is found that theoretically the following was the volume of water (given in millions of cubic metres) approximately used in the irrigation of all the crops grown in the perennially watered areas in the seasons mentioned below.

	1913–14.	1914–15.	1915–16.	1916–17.	Average.
Lower Egypt	13,940	16,741	14,694	16,878	15,563
Upper Egypt	6,446	5,954	6,433	6,470	6,326
Total . .	20,386	22,695	21,127	23,348	21,889

In comparing the averages given above with the Irrigation Department's estimate for water consumption based on that entering the perennial canals and raised from the Nile by pumps, the above figures are exceeded by about $6\frac{1}{2}$ milliards m^3 in respect to Lower Egypt and $1\frac{3}{4}$ milliards m^3 in the case of Upper Egypt. The difference can only be accounted for by the supplementary use to which canal water is put and by evaporation and seepage.[1]

In order then to keep entirely within the limits of safety with regard to the estimation of water requirements for the future extended cultivation scheme, it seems best to augment the above average figures for agricultural requirements by a percentage to reach the Irrigation Department's, apparently very generous, estimate, and to use a similar method with regard to estimations for new extensions.

[1] It will be seen that, in the Irrigation Department's estimate, an allowance was made of 4 milliards cubic metres which found its way back to the river, but in order to be completely on the safe side, I have assumed that the whole of this water was saved by the emptying of the basins and could not be deducted from the perennial area supply.

In this manner all water calculations for new land in Lower Egypt based upon the method employed for obtaining a figure for irrigation of crops alone will be augmented by 41 per cent. and in respect to Upper Egypt by 26 per cent.

On this basis the water requirements for Egypt, allowing for the completion of all the extensions and conversions previously mentioned, will be as follows :

Lower Egypt	Area. Eg. Acres.	Water required per annum. *Millions of cubic metres.*
Existing perennially watered area (average)	3,192,000	15,563
Cultivable but not yet cultivated area calculated for water on the basis of the requirements of the four northern provinces	950,000	5,009
Lake areas, calculated for water on a rice area basis	624,000	6,395
Theoretical water requirements for irrigation of cultivation only	—	26,967
Add 41 per cent. for supplementary water	—	11,056
Total water requirements of Lower Egypt	—	38,023
Upper Egypt		
Existing perennially watered area (average)	1,321,000	6,325
Cultivable but not yet cultivated area	245,000	6,215
Basin areas converted	1,053,000	
Theoretical water requirements for irrigation of cultivation only	—	12,540
Add 26 per cent. for supplementary water	—	3,260
Total water requirements for Upper Egypt	—	15,800
Total water requirements for whole of Egypt	—	53,823

Thus a very liberal estimate of the total amount of water which Egypt would annually require to take from the Nile, when the cultivated area has been extended to its utmost feasible limit and has been completely canalised for perennial watering, is 54,000,000,000 cubic metres. This leaves 36,000,000,000 cubic metres of water still unused, on the basis of an average volume of 90,000,000,000 cubic metres of discharge. This surplus could be utilised in the Sudan, and even then perhaps, given efficient drainage, would return to the river to an appreciable extent, and reach Egypt. A case of abnormality in flood conditions (such as occurred in 1913) would be adjustable in the future if the arrangement for the control of the whole volume

of the river, upon which the development of extensive new areas is dependent, were successfully carried out.

It is probable that if the northern lake areas were reclaimed, a great deal of water which at present flows down the perennial canals into these lakes would be saved, and it does not seem unlikely that the whole water requirements of Egypt, both for the irrigation of the ultimate possible extent of cultivation within the confines of a contourage to which it is reasonably easy for water to be supplied, as well as for any supplementary purpose on the present basis, would be met by less than 60 per cent. of the mean annual discharge of the Nile.

GENERAL ARTICLES

COTTON GROWING IN INDIA

The problems connected with the cultivation and production of cotton in India, and particularly those relating to the improvement of the staple of the native varieties and the introduction of long-stapled exotic kinds, have received the close attention of the Imperial Institute for many years. Large numbers of samples of Indian cottons, particularly those resulting from experimental investigations of the Agricultural Departments in India, have been examined at the Institute, and the results have in many cases been recorded in this Bulletin (compare especially 1912, **10**, 351 and 1917, **15**, 149). Moreover, the work of the Agricultural Departments on selection, hybridisation, and other problems connected with the improvement and extension of cotton growing in India has been carefully followed and has been reviewed from time to time in the pages of the Bulletin devoted to "Recent Progress in Agriculture and the Development of Natural Resources."

The need for an increased production of long-stapled cotton for the manufacturing industries of both Lancashire and India has been frequently brought to the notice of the Government of India and has received much attention. In view of the special emphasis which, during recent years, has been laid on the importance of growing long-stapled

cotton within the British Empire, the Indian Government appointed a special Committee in 1917 to investigate the possibilities of extending the cultivation of such cotton in India. In some parts of India there is already evidence to show that long-stapled cotton could be profitably grown, but in most of the cotton tracts attempts to produce such cotton have not met with success, as the yield per acre has not been sufficiently great to enable the long-stapled types to compete commercially with the existing short-stapled varieties. In these cases, therefore, it is necessary that special forms of long-stapled cottons should be evolved which will furnish a fibre of such yield and quality as to give a profit equal to that obtained from the existing kinds. In order that the cultivation of long-stapled cotton should repay the growers, it is essential that the higher prices commanded by such fibre should be secured to them by improvements in the system of marketing and the prevention of adulterating and watering the cotton.

The work imposed on the Committee was to include a study of the efforts which have been already made to establish long-stapled cottons in the various provinces of India, to draw attention to the possibilities of extending any methods which have proved successful, and to investigate the causes to which any failures may have been due. The Committee were also to study the local conditions in each cotton tract, the possibility of improving the present methods of ginning and marketing, and the means of preventing adulteration and damping. In addition to this, they were asked to report on the possibility of improving the accuracy of the cotton forecasts and of making the official statistics of greater value to the trade, and to submit recommendations as to the organisation required to develop the production of long-stapled cotton in areas considered suitable for the purpose.

An account of the proceedings of the Committee, the results of its enquiries and its recommendations has been published as the *Report of the Indian Cotton Committee* (Calcutta: Superintendent Government Printing, India, 1919). The Report covers 201 pages, and is provided with two cotton maps of India, irrigation maps of (1) the

Punjab, (2) the United Provinces and (3) Sind, and two plans of a model ginning factory.

In the introduction to the Report, it is pointed out that Lancashire is placed in a situation of considerable difficulty owing to its dependence on the United States for its raw material, and that it is most desirable that an alternative source of supply should be found within the British Empire. India is the largest cotton-producing country in the Empire and offers the greatest possibilities of effecting an increased output in the near future. It is pointed out that the average yield of cotton in India is only about 85 lb. per acre as compared with nearly 200 lb. in the United States and 450 lb. in Egypt. Moreover, the Indian cotton loses 10 per cent. more in the blow-room than American or Egyptian cotton, whereby its real yield per acre is reduced to about 76 lb. There is therefore an opportunity for the output to be greatly increased by means of cultural improvements.

Although efforts to promote the cultivation of long-stapled cotton suitable for the requirements of British cotton spinners and for the manufacture of the higher counts of yarn in India itself have been made for more than a century, comparatively little of such cotton is at present produced. Of the 4,000,000 or 5,000,000 bales of cotton now annually produced in India, very little is used in Lancashire; the average exports to the United Kingdom for the five years ending 1917–18 were only 215,000 bales, of which a large quantity was re-exported.

The Committee express the opinion that the only parts of India which, in the near future, are likely to be able to supply cotton suitable for this country, except for the comparatively unimportant purpose of hosiery yarns, are areas capable of producing large quantities of cotton of a length of 1 in. or a little more. At the present time the only such tracts are those parts of Madras in which Cambodia and karunganni are grown, and the Punjab where American cotton is being produced in increasing quantities. Egyptian and American varieties have been grown with success in Sind, and it is considered that large amounts of such cottons could be readily produced in that Province if perennial irrigation were ensured by

the construction of the Sukkur Barrage (see page 384). It is considered that, for at least ten years, India cannot be expected to furnish large commercial quantities of cotton with a staple longer than $1\frac{1}{16}$ in. It is stated, however, that India is already in a position to afford large supplies of cotton suitable for the manufacture of hosiery yarns. Several of the indigenous cottons are of excellent colour and strong, regular staple of $\frac{3}{4}$–1 in. in length. Such are the Northerns and karunganni of Madras, the Broach and kumpta cottons of Bombay, and the gaorani (Hinganghat) of Hyderabad. At present these cottons are mainly exported to Japan and the Continent for the manufacture of hosiery which is being increasingly used in India as underclothing by the better classes.

The Report is divided into two parts, the first dealing with the questions of agriculture and irrigation, and the second with the commercial aspects of the subject. As the conditions vary greatly in different parts of India, each Province is treated separately in the first part, and the principal features of this section are summarised in the following pages. In the case of each Province, recommendations are made with reference to the additions or alterations required in connection with the staff of the Agricultural Department in order to increase its efficiency.

The second part of the Report is devoted to questions of special interest to the trade. The subject of marketing the cotton in such a way as to secure an adequate return to the cultivator is discussed ; the unsatisfactory character of the present system is pointed out, and the establishment of cotton markets is advocated on the lines of those now existing in Berar. Recommendations are made with reference to the extension of the number and activities of co-operative sale societies and the organisation of auction sales. Among other subjects dealt with are those of buying agencies, the standardisation of weights, the prevention of the adulteration, mixing and damping of cotton, improvements in the methods of picking, the licensing of ginning and pressing factories, and the improvement of the cotton forecasts and other statistical returns. In the last two chapters, recommendations are made with regard to the formation of (1) a Central Association, to

replace the seven distinct organisations which now control the cotton trade in Bombay, and (2) a Central Cotton Committee to secure co-ordination and co-operation and to act as an advisory body to the Government and the trade on all matters relating to cotton.

PUNJAB

The average area devoted to cotton in the Punjab during the five years ending 1916–17 was 1,370,000 acres, in addition to which an average of 146,000 acres was planted in Native States. This area of 1,516,000 acres was 6·7 per cent. of the total area under cotton in India.

The varieties of cotton grown in the Punjab are as follows: (1) *Gossypium hirsutum*, consisting almost entirely of the Upland Georgian type, now known as Punjab American. At least three-fourths of this crop is now of the 4F type, the remainder being a mixture of American types, including *G. mexicanum* or New Orleans which is rapidly disappearing. The 4F cotton has a staple of $\frac{7}{8}$ in. and a ginning percentage of 32. (2) *G. indicum* (yellow flowered), which is the predominant indigenous cotton throughout the Punjab, except in small tracts of the Western districts; it has a staple of $\frac{1}{2}$–$\frac{3}{4}$ in. and a ginning percentage of 33. (3) *G. indicum Mollisoni* (white flowered), which occurs in small quantities throughout the Province, and has a staple of $\frac{3}{8}$–$\frac{1}{2}$ in. and a ginning percentage of 40. (4) *G. neglectum.* This species exists in three varieties, viz. *G. neglectum malvense* (broad-lobed leaf) with a staple of $\frac{5}{8}$ in. and a ginning percentage of 30; *G. neglectum verum* (narrow-lobed leaf), with a staple of $\frac{1}{2}$–$\frac{5}{8}$ in. and a ginning percentage of 35; and *G. neglectum roseum* (narrow-lobed leaf and white flower), with a staple of $\frac{3}{8}$ in. and a ginning percentage of 37. (5) *G. sanguineum*, a variety peculiar to the Punjab which predominates over *G. indicum* in parts of the Jhang and Multan districts, and is often grown practically pure; it has a staple of $\frac{5}{8}$ in. and a ginning percentage of 32. (6) *G. obtusifolium hirsutus*, occurring only in the Dera Ghazi Khan, Muzaffargarh and Multan districts, which has a staple of $\frac{5}{8}$–$\frac{3}{4}$ in. and a ginning percentage of 33.

The indigenous varieties grow largely in admixture with one another, almost every field containing at least four varieties. In the south-east of the Province, *G. neglectum roseum* is the most important variety with the exception of *G. indicum*. A high proportion of the varieties of *G. neglectum* is found in the cotton fields of the Hissar and Ambala districts. Further north the mixture contains *G. indicum* as the principal kind, and this is followed by the yellow-flowered *G. neglectum*.

With regard to the indigenous cottons, it is considered that efforts should be made to evolve a strain either of *G. indicum* or of *G. neglectum malvense* which would give a better profit per acre than any of the constituents of the mixture now grown, and also to obtain a more uniform staple than that at present produced which should be about ⅝ in. in the central and western tracts and ½ in. in the eastern tract.

Cotton is usually sown broadcast in the Punjab, but sometimes the seed is dropped by hand behind the plough. In the Canal Colonies, sowing in lines is being adopted for American cotton and over 8,000 acres were planted in this way in 1917. The Committee express the opinion that the latter method of sowing, in conjunction with the practice of hoeing between the rows, would lead to a considerable increase in production and that the Agricultural Department should endeavour to promote its extension. The cotton crop usually follows "toria" (*Brassica campestris*), sugar cane, maize, gram, or wheat. It is considered that "toria" is the most suitable crop to precede cotton and that this rotation should be generally recommended. The average yield of cotton in a normal year varies from 80 lb. on non-irrigated land to 160 lb. on irrigated.

American cotton has been submitted to careful selection at the Agricultural College, Lyallpur, and as a result the 4F variety has been developed. The yield of this variety is greater than that of the native kinds and is less likely to be affected by excessive rain. At least 300,000 acres are now devoted to the pure 4F cotton, and between 50,000 and 60,000 acres to other American varieties. With a view to ensuring that the American cotton should secure

adequate premiums over the native kinds, auction sales have been instituted under the supervision of the Agricultural Department. The fact that the Agricultural Department collects the seed-cotton and guarantees its purity has enabled some of the large exporting firms to compete against the local merchants and has resulted in much larger premiums being obtained than would otherwise have been the case. Recently, private auctions have been started, and this development is regarded as very promising. The Committee recommend that the work connected with these auction sales and with the distribution of seed should be devolved on organisations of zamindars, whether in the form of co-operative societies or otherwise, as soon as possible.

The seed from the best cotton sold at the auctions is reserved for the Agricultural Department, who supervise the ginning and distribute the seed to agents who sell it on commission. In order to ensure a supply of pure seed, 10 acres are set apart on the Lyallpur farm for growing selected seed. About 40 maunds of seed are thus produced, of which 5 maunds are sent to the Government seed-farm at Montgomery and the remainder is distributed to certain large estate owners, who undertake to plant it and return the resulting seed to the Agricultural Department. It is estimated that in this way sufficient seed can be produced for the 465,000 acres which is the maximum area expected to be planted with American cotton during the next few years. There is therefore no need for the establishment of special seed-farms for American cotton. Such farms will, however, be required if superior varieties of indigenous cotton are evolved, or if there is any extension of American cotton in other parts of the Province. The Committee suggest that steps should be taken soon to secure suitable sites.

Selection work with American cotton is being continued at Lyallpur and several new varieties are being tested. One of these, known as 280F, furnishes a cotton with a staple at least ⅛ in. longer than that of 4F, but gives a smaller yield and has a lower ginning percentage. Another form, 285F, is considered to give an even better cotton than 280F, but its yielding power has not yet

been investigated. The Committee recommend that further experiments should be made with these two varieties.

American cotton has hitherto been grown only in the Canal Colonies, but it is considered that the possibility of cultivating it under well irrigation in the Eastern Punjab and under the inundation canals in the south-west of the Province should be thoroughly tested.

Of the average area of 1,370,000 acres planted with cotton in the five years ending 1916–17, about 1,071,000 acres, or 78·3 per cent., were under irrigation from either canals or wells. The whole of the American crop is necessarily grown under irrigation, owing to the fact that this crop has a longer growing season than the indigenous kinds. The extension of the cultivation of American cotton thus depends almost entirely on an increase in the irrigation facilities, and the Committee have therefore made an exhaustive examination of the conditions of each irrigated tract in the Punjab.

The canals are dealt with in the Report in order from east to west. The Western Jumna Canal irrigates the important native cotton tract of which Hissar is the centre. Owing to the late rise of the Jumna River, the canal does not attain its full capacity until the beginning of June, and the cultivation must therefore be restricted to short-stapled cotton unless an American type can be evolved which is specially adapted to the local conditions. On the Sirhind Canal, the soil is not suitable for the growth of long-stapled cotton, except in parts of the eastern and northern tracts, especially those in the Native States territory where American cotton has already been cultivated. On the Upper Bari Doab Canal, American cotton is at present grown only in the Chunian Colony. It is expected that, except in this and the contiguous tracts, native cotton will continue to be produced unless a suitable American form can be developed. On the five linked canals, viz. the Upper and Lower Jhelum, the Upper and Lower Chenab, and the Lower Bari Doab Canals, nearly the whole of the American cotton crop of the Punjab is at present grown, and it is only in these areas that any great extension of this cotton can be anticipated in the immedi-

ate future. With regard to the inundation canals, the Sidhnai Canal is only semi-perennial and there is no assured supply of water during April, May, September and October. There are numerous wells in this tract, however, which would furnish supplies for early sowings and late waterings. In the case of the Shahpur inundation canals, the area irrigated varies greatly from year to year, and no increase in the area devoted to cotton can be looked for unless the proposal to construct a branch of the Lower Jhelum Canal to irrigate the whole of the tract now served by these canals is carried into effect.

In connection with the cultivation of long-stapled cotton, the irrigation projects now under consideration are of great importance. These include (1) a scheme of canals for the Sutlej Valley, a tract well suited to American cotton provided that perennial irrigation can be assured; (2) the Haveli project, which provides for a weir across the Chenab River below its confluence with the Jhelum, from which a canal on the left bank will irrigate a new area between the irrigation boundary of the Lower Chenab Canal and the river Ravi and will supply water to the whole of the areas now irrigated by the Sidhnai and Chenab inundation canals, whilst a canal on the right bank will irrigate the "Kachi" tract of the Jhang district, improve the conditions of the Karam inundation canal and extend irrigation to new areas in the north of the Muzaffargarh district; (3) the Sind Sagar Doab project, which will probably provide for a perennial canal from the left bank of the Indus near Mari, affording irrigation for a large tract in the Mianwali district and smaller areas in the Shahpur and Muzaffargarh districts; and (4) the Woolar Lake project for utilising the water of the Woolar Lake in Kashmir.

The prospects for American cotton on the various canals are summarised in the table on p. 375.

It is seen from these figures that an area of 465,000 acres of American cotton under existing canals and of 200,000 acres under projected canals may be anticipated. The three projects mentioned in the table, however, will affect the supply in the Indus and, unless further progress in irrigation in the Punjab is to be suspended in view of its

Canal area.	Total area under cotton anticipated.	Actual area under American cotton in 1917.	Estimated area under American cotton by 1920.
	Acres.	*Acres.*	*Acres.*
Upper Bari Doab Canal . .	160,000	1,257	7,000
Lower Jhelum Canal . .	90,000	35,292	55,000
Lower Chenab Canal . .	245,000	137,200	190,000
Upper Jhelum Canal . .	50,000	3,181	25,000
Upper Chenab Canal . .	50,000	8,926	20,000
Lower Bari Doab Canal .	180,000	90,342	150,000
Sidhnai Canal	35,000	743	10,000
Lower Sutlej Inundation Canals.	30,000	—	8,000
Total			465,000
Projects :			
Sutlej River Projects . .	325,000	—	70,000
Haveli Project . . .	100,000	—	70,000
Sind Sagar Doab Project .	100,000	—	60,000
Total . . .			200,000

effect on the water supplies of Sind, it is of the utmost importance that the construction of the Sukkur Barrage (see page 384) should be undertaken as soon as possible.

A large part of the Punjab is irrigated by means of wells which at present are worked almost exclusively by bullock power. It is suggested that an investigation should be made of the possibilities of tube wells and of pump irrigation.

Reference is made to the Bahawalpur State, situated in the south-west corner of the Punjab, which offers exceptionally favourable prospects for the cultivation of American cotton. The rainfall is very small, but it is understood that the Bahawalpur Darbar has devised a scheme for the construction of perennial canals which would render possible the irrigation of 1,291,410 acres annually.

North-West Frontier Province

The cotton crop in the North-West Frontier Province is of comparatively small importance, the net area devoted to cotton during the five years ending 1916–17 being only 46,000 acres, or about 0·2 per cent. of the total area under cotton in India during that period. The cultivation is chiefly carried on in the Peshawar and Dera Ismail Khan districts. The varieties grown are much the same as those

cultivated in the Punjab, the predominant types being *Gossypium neglectum verum* and *G. neglectum malvense.* The ginning yield of the mixture is only about 25–26 per cent., but the quality of the staple, especially that produced near Peshawar, is superior to the native cotton of the Punjab. It is suggested that selection work should be carried out with this cotton with a view to improving the ginning percentage. American cotton has been grown experimentally at the Government Farm at Peshawar, and two varieties, viz. "Hartsville" and "Mexican Big Boll," have given promising results. In the Dera Ismail Khan district, American cotton has been cultivated with success, but only on a very small scale owing to the lack of an assured supply of water.

In 1915–16, the area devoted to cotton in this Province was 26,294 acres, of which 16,755 acres were irrigated. It is considered that great expansion may take place in that part of the Peshawar district which is irrigated by the Upper Swat River Canal. This canal was opened in 1914–15, and when fully developed will be capable of watering 348,987 acres annually. This tract appears well suited to native cotton, and the possibilities of this and also of American varieties should be carefully tested. Another area which offers possibilities for the extension of cotton growing is that part of the Dera Ismail Khan district which is irrigated by the Paharpur Inundation Canal. This canal takes off from the Bilot Creek of the Indus, and it is proposed to make it perennial by constructing a barrage across the Bilot Creek. It is estimated that if this project is carried out, about 12,000 acres will be rendered available for cotton and would be well adapted for American varieties. It is considered desirable that the agricultural authorities in the North-West Frontier Province should keep in touch with the Punjab Agricultural Department, as many of the problems connected with cotton growing are common to both Provinces. Moreover, the latter Department would be able to assist in marketing American cotton and improved native kinds, and in ensuring that the growers receive a fair price for their crops.

United Provinces

During the five years ending 1915–16, the net area devoted to cotton in the United Provinces was 1,239,000 acres, or 5·6 per cent. of the total cotton area of India, and, in addition to this, the Native States of the Province had an average of 13,000 acres under the crop.

Cotton is grown to some extent in all parts of the United Provinces, but the chief areas are in the west, and especially in the Bulandshahr, Muttra, Aligarh and Agra districts. The soil of the main growing tract consists chiefly of the alluvium of the Gangetic Plain. Of the total area cultivated in the five years ending 1915–16, 31·3 per cent. was irrigated.

The native cotton of the United Provinces is known commercially as "Bengals," "ordinary Bengals" having a staple of $\frac{3}{8}$–$\frac{1}{2}$ in. and "fine Bengals" $\frac{1}{2}$–$\frac{5}{8}$ in. The cotton plants consist of a mixture of the following varieties: *Gossypium indicum* (staple $\frac{3}{4}$ in., ginning percentage 32), *G. indicum Mollisoni* (staple $\frac{3}{8}$–$\frac{1}{2}$ in., ginning percentage 40), *G. neglectum malvense* (staple $\frac{5}{8}$ in., ginning percentage 30), *G. neglectum verum* (staple $\frac{1}{2}$–$\frac{5}{8}$ in., ginning percentage 38), *G. neglectum bengalense* (staple $\frac{5}{8}$–$\frac{3}{4}$ in., ginning percentage 33), *G. neglectum roseum* (staple $\frac{3}{8}$ in., ginning percentage 38), and *G. neglectum cutchicum* (staple $\frac{3}{8}$ in., ginning percentage 36). The first two of these are only occasionally present, but the others are found throughout the Province. *G. neglectum roseum* (the Aligarh white-flowered cotton) is grown in a pure state on about 120,000 acres in the vicinity of Aligarh.

The cotton seed is sown broadcast as in the Punjab. It is suggested that efforts should be made to encourage the practice of sowing in lines, and that a detailed study of sowing methods should be carried out by the Agricultural Department. The cotton is usually planted after wheat. In the tracts irrigated by canals, a mixture of barley and peas is often grown after native cotton, but this is not possible in the case of American cotton owing to the longer season of the latter. In these circumstances, it is considered that the possibility of growing a fodder crop with both native and American cotton in September or October should be tested.

Although early efforts to cultivate American cotton in the United Provinces did not meet with success, further trials were started in 1870 at Cawnpore and ultimately resulted in the establishment of the acclimatised variety known as Cawnpore American. Owing to difficulties connected with the sale of this cotton, it is now collected by the Government at a premium over the native cotton. The demand for seed of this variety is increasing, and it was expected that, during 1919, an area of 4,000–5,000 acres would be planted with it. Botanical work on the Cawnpore American cotton is being conducted by Mr. Burt, Deputy Director of Agriculture in charge of the Central Circle, and has resulted in the isolation of some very promising strains. Special attention is being devoted to the production of a rough-leaved type, such types being less susceptible to insect attack than the smooth-leaved varieties, and it is considered that a cotton of this kind should be given out as soon as possible in order to render the crop more regular in length and quality than it is at present.

Experiments on the American "Buri" cotton have been carried out at Aligarh by Dr. Parr, Deputy Director of Agriculture, but have not led to definite conclusions. It is recommended that these experiments should be abandoned and that the work should be concentrated on the Cawnpore American variety.

Attempts to improve the native cotton have been made by Mr. Leake, Economic Botanist to the United Provinces, by crossing and selection on Mendelian lines, and varieties of fair length of staple and high ginning percentage have been isolated. Among these, a variety known as K22, with a staple length of $\frac{3}{4}$ in. and ginning percentage 37, and another, known as K28, with staple length $\frac{7}{8}$ in. and ginning percentage 37–40, are regarded as promising and are being further tested, the former on a field scale. Meanwhile it is suggested that a field selection known as the "Jalaun selection" which has been made by Mr. Burt and is regarded as equal to "fine Bengals" should be distributed to the growers and that further selection work on it should be simultaneously carried on.

As the result of a study of the native cottons of the United Provinces by Dr. Parr, it was found that *G. neglectum roseum* ("Aligarh white-flowered cotton") was the most profitable variety to grow, as it gives a larger yield than the local mixture, has a ginning percentage of 38–39 as compared with 33 for the latter, and furnishes lint of superior quality and whiter colour. The length of staple, however, is barely $\frac{3}{8}$ in. and for this reason the cotton is now regarded with disfavour by the trade. In view of this and of the fact that no selection work on the native cotton has been done for some years, the Committee recommend that no further steps should be taken to promote the extension of the Aligarh white-flowered cotton until it has been proved that no better variety of *G. neglectum* can be found which will be equally profitable to the grower, and also suggest that a detailed survey of the indigenous cottons of the Province should be carried out at once, selections being made at the same time which should be tested on the Government farms. It is not thought that the cotton tracts of the United Provinces as a whole are suitable for a cotton of more than about $\frac{3}{4}$ in. in staple, but if cotton with a uniform length of $\frac{5}{8}$ in. could be substituted for the present mixture, it would constitute a considerable improvement.

In connection with the extension of Cawnpore American cotton and the production of superior varieties of native cotton, the Committee express the opinion that the area and number of seed farms will need to be largely increased in order to enable the Agricultural Department to retain control over the distribution of the seed.

With regard to the marketing of the cotton, it is suggested that the possibility of holding Government auctions on the lines which have proved successful in the Punjab should be investigated and that, if possible, cotton markets should be established at important centres, such as Aligarh and Muttra.

The whole of the American cotton in the United Provinces is grown under canal irrigation; its extension is hampered by the fact that the irrigation seldom serves the whole village, and hence only a part of the village area can be planted with such cotton. Trials have been

made to concentrate the water supply in certain channels irrigating tracts suitable for American cotton and concessions are granted to cultivators willing to grow this variety. The Committee recommend that these concessions should be continued until their effect on the area devoted to American cotton is definitely established. It is considered probable that if a sufficiently high premium for American cotton can be assured, 100,000 acres on the Ganges Canals and 35,000 acres on the Agra Canal will eventually be planted with such cotton.

In many parts of the United Provinces, irrigation is entirely dependent on wells and there is therefore a wide field for the development of pump irrigation. During the last few years, many tube wells and pumps worked by power have been successfully installed by the Agricultural Department, and it is recommended that the whole question should be thoroughly investigated at an early date.

Central Provinces and Berar

The net area planted with cotton in the Central Provinces and Berar during the five years ending 1916–17 was 4,475,000 acres, or 20 per cent. of the total cultivated area of these Provinces. In Berar alone the percentage of the cotton area to the total cultivated area was still greater, and in 1914–15 amounted to as much as 45. The most important cotton tracts are the four districts of Berar and the adjacent districts of Nimar, Wardha and Nagpur. The soil of Berar is chiefly the well-known "black cotton soil," a rich, black, deep, fertile loam. In the Nagpur plain, the great cotton tract of the Central Provinces, the soil is a loam of somewhat less depth than that of Berar.

The cotton now grown in the Central Provinces and Berar consists chiefly of a mixture, in which the following varieties of *Gossypium neglectum* predominate: *G. neglectum malvense* (staple $\frac{3}{4}$–$\frac{7}{8}$ in., ginning percentage 25), *G. neglectum verum* (staple $\frac{5}{8}$–$\frac{3}{4}$ in., ginning percentage 30), *G. neglectum roseum* (staple $\frac{1}{2}$–$\frac{5}{8}$ in., ginning percentage 40) and *G. neglectum cutchicum* (staple $\frac{1}{2}$–$\frac{5}{8}$ in., ginning percentage 38). The average length of staple of the mixture is $\frac{5}{8}$–$\frac{3}{4}$ in., and average ginning percentage 33–35.

The variety known as *G. neglectum roseum* has been isolated by the Agricultural Department and is now grown on at least 700,000 acres. Tests carried out at the Imperial Institute (cf. this BULLETIN, 1912, **10**, 359; 1917, **15**, 157, 162) showed that the length of staple of this cotton varies from 0·6 to 1 in., but it is considered that the ordinary staple is not more than $\frac{1}{2}$–$\frac{5}{8}$ in., the cotton sent to the Imperial Institute having been grown under special conditions on the Government farms at Akola and Sindewahi.

The variety known as "Bani" (*G. indicum*), which has a staple of 1–1$\frac{1}{8}$ in. and ginning percentage 25, and in its pure state is one of the finest native cottons of India, has nearly disappeared from the Provinces except as a constituent of the mixture, and it is probable that not more than 10,000 acres are now planted with it, including 6,000 acres grown as a rabi (cold season) crop in Chanda under the name of "Chanda cold-season jari." Upland Georgian (*G. hirsutum*), with a staple of $\frac{3}{4}$–$\frac{7}{8}$ in. and ginning percentage 31, is not now grown pure. Another type of *G. hirsutum*, known as "Buri" (staple $\frac{7}{8}$–1 in. and ginning percentage 31), is now being grown in a pure state on about 2,000 acres. Cambodia cotton (*G. hirsutum*, Mill) is cultivated under irrigation on a small area of the Chhattisgarh Division in the east of the Central Provinces.

The cotton crop of the Central Provinces and Berar is grown almost entirely without irrigation. The land is seldom ploughed unless it has become infested with weeds, and is merely scratched with a blade harrow before sowing. A narrower form of blade harrow is used for interculture, the cotton usually being sown in lines. Although these harrows are fairly satisfactory, they require to be supplemented by an implement which will break up the soil well at the end of the rains, and for this purpose the Agricultural Department have introduced an improved hoe, known as the Akola hoe. The Committee recommend that efforts should be made to extend the use of this hoe.

The cotton is generally grown in alternate years in rotation with juar (*Sorghum vulgare*), but sometimes is planted on the same land for two or three years in succession. It is suggested that if a leguminous fodder crop

were grown instead of or with the juar, the yield of cotton would be appreciably increased.

Efforts to grow long-stapled cotton in the Central Provinces and Berar have been mainly directed to the improvement and extension of the indigenous Bani or Hinganghat, but this cotton has not been able to compete with the coarser varieties which are superior in yield and ginning percentage, and are therefore more profitable to the grower. American Upland Georgian cotton was introduced many years ago and still survives as a constituent of the mixture of varieties now grown.

During recent years the work of the Agricultural Department has been concentrated on the spread of the *G. neglectum roseum* cotton, and a co-operative system has been organised for the production and distribution of the seed. This system, which has been briefly described in this BULLETIN (1915, **13**, 488), has achieved remarkable success, and about one-sixth of the total cotton area of the Central Provinces and Berar is now planted with the *roseum* variety. In addition to this, there is now a much higher proportion of *roseum* in the ordinary "jari" mixture.

The Committee, whilst fully recognising the value of the work done by the Agricultural Department on the *roseum* cotton, consider that efforts should be made to evolve a superior type of *G. neglectum* with a length of staple of $\frac{7}{8}$ in. and a ginning percentage of about 35. They recommend that duplicate tests should be carried out on an extensive scale with a view to the accurate determination of the comparative yields of *roseum* and other varieties, and suggest that, if it is found impossible to obtain a superior type of *G. neglectum* or *G. indicum* or a hybrid between them which would be as profitable to the growers as *roseum*, vigorous measures should be taken to cover the whole of the cotton area of the Provinces with the *roseum* variety.

The most suitable soils in the Central Provinces for the cultivation of American cotton are the light, porous, lateritic soils, or "bhata" soils, of the Chhattisgarh Division. Cambodia cotton has been grown successfully under irrigation on the Government farm at Chandkuri, near Raipur, and on cultivators' land in that neighbour-

hood. The conditions of irrigation in this area, however, are such that not more than 7,000 acres of irrigated land are likely to be available for cotton in the near future, but judging from the results obtained at Chandkuri the cotton produced should all be of excellent quality and 1–1⅛ in. in length of staple. It is recommended that efforts should be made to provide water for as much of the "bhata" land as possible, and that the possibility of irrigation by pumping in this district should be investigated. There appears to be a possibility of growing Cambodia cotton without irrigation on the black soil areas of Western Chhattisgarh where the rainfall is high, and it is suggested that this question should be investigated.

Buri cotton has been found of value for areas infected with wilt disease, and it is considered desirable that the Agricultural Department should continue to be in a position to supply pure seed of this variety for use in such areas.

Sind

The area under cotton in Sind during the ten years ending 1916–17 averaged 268,000 acres, exclusive of 7,000 acres in the Native State of Khairpur. For the five years ending 1916–17 the average cotton area of Sind was 1·2 per cent. of the total cotton area of India. The whole of the cotton is grown under irrigation. The soil is an alluvial loam similar to that of the Punjab but of somewhat stiffer texture. In many tracts the soil resembles that of the Egyptian delta.

The native cottons of the Province consist of a mixture of the same varieties as those grown in the Punjab, with the exception of *Gossypium sanguineum* and the addition of *G. neglectum cutchicum*. The average length of staple of the mixture is ⅜–⅝ in. and the average ginning percentage 35. Sind cotton is rougher, stronger and whiter than that of the Punjab and the crop gives a larger yield, amounting in favourable seasons to 800 lb. of seed-cotton per acre as compared with 520 lb. on irrigated tracts of the Punjab. In addition to the native cotton, certain small areas are planted with American cotton (*G. hirsutum*).

Egyptian cotton (*G. barbadense*) is now grown only on the Government farms.

Experiments which have been made with Egyptian and American cotton in Sind (cf. this BULLETIN, 1911, **9**, 217) have demonstrated that these varieties can be successfully cultivated in the Province. Efforts to grow such cotton on a commercial scale have failed, however, owing chiefly to the unsatisfactory character of the irrigation. Other causes contributing to the failure were the practice of importing fresh seed instead of developing acclimatised varieties, the inferior methods of cultivation, and the fact that the growers were unable to obtain the full value of their cotton.

The canal systems on which the present irrigation of Sind depends are entirely dependent on inundations from the river Indus for their supplies. They usually come into flow about the beginning of June and cease to flow during September, but full supplies are generally obtained for only 30–40 days. The result of these unfavourable conditions is that practically the only cottons cultivated are short-stapled varieties, which can be grown in the short season during which water is available.

In order to ensure an ample and steady supply of water for the cotton-growing tract of Sind, the Sukkur Barrage project has been prepared and is now under consideration. This provides for a barrage across the Indus near the Sukkur-Rohri Gorge, a canal from the right bank of the Indus which will take over the irrigation in the Ghar and Western Nara Canals Districts, and a canal, to be known as the Rohri-Hyderabad Canal, from the left bank of the Indus, which will take over the irrigation in the Nasrat and Hyderabad Canals Districts and will also irrigate part of the tract commanded by the Fuleli Canal. It also provides for improvements to the Jamrao Canal and the canals of the Eastern Nara Canals District.

It is considered that there is no prospect of American or Egyptian cotton being grown in Sind on any extensive scale unless some such irrigation scheme is carried out. It is estimated that if the Sukkur Barrage and the connected canals are constructed, an area of at least 400,000 acres of long-stapled cotton may be anticipated, made up

as follows: Rohri-Hyderabad Canal, 250,000 acres; Jamrao Canal, 100,000 acres; Eastern Nara Canals, 50,000 acres. Under the present conditions of water supply, there is no likelihood of long-stapled cotton being grown on any of the canals not affected by the Sukkur Barrage project. In the irrigation scheme under consideration, provision is made for an intensity of 50 per cent., which means that one-half of the area will be irrigated annually. Although this is a great advance on the present conditions, under which the intensity is only 33⅓ per cent., it is recommended that in constructing the canals the possibility of enlarging them to carry supplies sufficient for an intensity of 75 per cent. should be taken into account. It is also suggested that the question of water-logging should receive attention, and that a careful survey of the subsoil water table should be made, either before or during the construction of the Sukkur Barrage.

With regard to the work of the Agricultural Department of Sind, the Committee consider that, if eventually it should be decided to abandon the Sukkur Barrage project, the work on exotic cottons should be discontinued. Meanwhile, the Department should not actively stimulate the cultivation of American cotton, but should nevertheless continue to supply seed to cultivators who desire it, and should assist in marketing their crops. Efforts should be made to produce improved strains of American "Triumph" and Egyptian "Mitafifi" and also to develop varieties of native cotton of longer staple and higher ginning percentage than those at present grown. It is also recommended that three pumping stations should be established for experimental work on problems which will arise on the completion of the Sukkur Barrage scheme, such as improvements in cultivation, suitable rotations and the cultivation of berseem.

Bombay

The average area devoted to cotton in Bombay (exclusive of Sind and Native States) during the five years ending 1916–17 amounted to 3,962,000 acres, or 15·1 per cent. of the total cultivated area of the Presidency. The

percentage of the area under cotton to the total cotton area of India during the same five years averaged 17·7. In addition, the Native States in the Presidency had an average area of 2,191,000 acres planted with cotton during the same quinquennium, or 9·8 per cent. of the total cotton area of India; these figures are exclusive of the Baroda State which is dealt with separately (see page 398).

The cotton-growing tracts of the Bombay Presidency may be considered in four main divisions, viz. (1) the "Dholleras" tract, comprising the greater part of North Gujerat, *i.e.* the Ahmadabad and part of the Kaira and Panch Mahals Districts, the adjoining parts of the Baroda State, and the greater part of Kathiawar; (2) the "Broach" tract, which lies immediately south of the "Dholleras" tract, and consists of Southern Gujerat, including the Broach and Surat districts and the adjacent part of the Baroda State, particularly the Navsari district; (3) the "Khandesh" tract, which comprises the districts of East and West Khandesh, Nasik, Ahmednagar and Sholapur, and the northern part of the Bijapur district; and (4) the "Kumpta-Dharwar" tract, which includes the districts of Dharwar and Belgaum, and the greater part of Bijapur as well as several Native States, and thus comprises nearly the whole of the Karnatak.

The soils of the Presidency are mainly of two kinds, viz. "kali," the black cotton soil, such as occurs in Broach and Surat, and "goradu," deep alluvial soils varying from the drift sands of Ahmadabad to the rich loam of Kaira.

With regard to the varieties of cotton grown in the Presidency, the "Dholleras" cotton previous to 1900 consisted chiefly of "lalio," a variety of *Gossypium herbaceum*, with a staple of $\frac{5}{8}$–$\frac{3}{4}$ in. and ginning percentage 33. This cotton has now been largely replaced by a mixture of varieties. In the neighbourhood of Viramgam in the Ahmadabad district and in parts of Kathiawar and Cutch, "wagad" is grown, a nearly pure type of *G. herbaceum*, with staple $\frac{3}{4}$–$\frac{7}{8}$ in. and ginning percentage 33. In the Kaira and Panch Mahals district and in the Daskroi taluka of Ahmadabad the cottons grown are "kanvi," a mixture of Broach and "goghari," with staple $\frac{1}{2}$–$\frac{5}{8}$ in. and ginning percentage 35, and "goghari," an inferior

variety of *G. herbaceum*, with staple $\frac{1}{2}$–$\frac{5}{8}$ in. and ginning percentage 40. Over large tracts of Ahmadabad and Kathiawar, the principal cotton grown is "mathio," a mixture resembling that of Khandesh with the addition of *G. neglectum kathiawarense*; of the other varieties of *G. neglectum* in the mixture, those which predominate are *G. n. cutchicum* and *G. n. roseum*; the length of staple of the mixture is $\frac{1}{2}$–$\frac{5}{8}$ in. and the ginning percentage 32. In the Kaira district there is a perennial variety of *G. obtusifolium* grown, which is known as "rozi" or "jaria" and has a staple of $\frac{1}{2}$–$\frac{5}{8}$ in. and a ginning percentage 35. Reference may also be made to the Bourbon cotton (*G. purpurascens*) which is still found in hedges in the Ahmadabad and Kaira districts. In these two districts, Cambodia has been grown to some extent but has now been almost entirely abandoned in favour of "lalio," which is regarded as more profitable and more easily marketable.

In the "Broach" tract, *G. herbaceum* is the only species grown, with the exception of small quantities of Bourbon cotton (*G. purpurascens*). In the Broach district north of the Narbada and the adjacent parts of Baroda, the excellent cotton formerly grown has recently been largely replaced by the inferior "goghari" cotton, which has become very popular owing to its high ginning percentage. It is anticipated that this variety will continue to extend not only in the district mentioned but also in the Surat and Navsari tracts, unless steps are taken immediately to check it. The cotton grown in the Surat tract has a staple of $\frac{7}{8}$ in. and ginning percentage 32, whilst that of the Navsari tract has a staple of 1 in. and ginning percentage 31.

The cotton of the "Khandesh" tract consists of a mixture of varieties of *G. neglectum* such as is grown in the Central Provinces and Berar. It contains *G. n. malvense*, *G. n. verum*, *G. n. cutchicum* and *G. n. roseum*, together with a small proportion of the Upland Georgian variety (*G. hirsutum*); its average staple is $\frac{1}{2}$–$\frac{5}{8}$ in. and its ginning percentage 32. This mixture is now being gradually replaced by *G. n. roseum* and it is estimated that 30,000 acres are now planted with this variety in a pure state; the staple of this cotton in Khandesh is $\frac{3}{8}$–$\frac{1}{2}$ in. and the ginning percentage 38.

In the "Kumpta-Dharwar" tract, the chief cotton grown is "kumpta," a variety of *G. herbaceum* with a staple of ⅞ in. and ginning percentage 26. The cotton known as "saw-ginned Dharwar" or "Dharwar American" is a mixture of Upland Georgian (*G. hirsutum*) and New Orleans (*G. mexicanum*); it has a staple of ¾–⅞ in. and ginning percentage 30. This cotton is commonly grown in admixture with "kumpta," but as the latter variety ripens later, both kinds are marketed in a fairly pure condition. Cambodia cotton (*G. hirsutum*) is now grown on about 5,000 acres in the Gadag and Ron talukas of the Dharwar district, and Dharwar Broach, introduced into the tract about ten years ago by the Agricultural Department, is grown on about 5,000 acres in the west of the Dharwar district.

The methods of cultivation practised in the Bombay Presidency are very good, especially in the Broach tract. The seed is sown in lines by means of drills, and in the Broach tract the seedlings are thinned out. The most usual rotation is cotton and "juar" (*Sorghum vulgare*), but in the Broach tract, "lang" (*Lathyrus sativus*), wheat, or "tur" (*Cajanus indicus*) often take the place of "juar." Not infrequently, however, cotton follows cotton, especially in the Surat and Navsari districts, and fallowing is largely practised. Efforts have been made by the Agricultural Department to introduce leguminous crops, especially ground nuts, into the rotation, and to encourage the cultivation of "sann" hemp (*Crotalaria juncea*) as a green manure. Both practices are now being adopted on a large scale in the Broach tract, and the cultivation of ground nuts in alternation with cotton is extending rapidly in Khandesh.

After reviewing the various attempts which have been made to introduce exotic cottons into Bombay, the Committee express the opinion that there is little prospect for such cotton except in the Kumpta-Dharwar tract, and that the Agricultural Department are fully justified in devoting attention to the improvement of the indigenous varieties.

Little work has been done hitherto on the varieties of which the "Dholleras" mixture is composed, and the

Committee recommend that the relative value of these constituents should be definitely ascertained, so that it may be possible to decide on the best steps to be taken with regard to them. Meanwhile, efforts should be made to maintain the purity of " wagad " and to restore " lalio " to its former degree of purity.

In the Broach tract, experiments have been made at the Surat farm with the native cottons in the production of hybrids and selected strains, but the improved varieties obtained have not yet been extensively cultivated, the maximum area planted with them during recent years amounting to only 1,200 acres. It is suggested that the Agricultural Department should endeavour to evolve a type of Broach cotton for the " goghari " cotton area which should be equal in staple to the Broach cotton when grown pure and superior to it in yield and ginning percentage. It is also recommended that the work on the Surat farm should be continued on the present lines, but that efforts should be made to evolve strains for the Surat tract equal or superior to the best Navsari cotton. Only one such strain should be given out at a time.

In the Khandesh tract, work has been carried out on the separation of the constituents of the local mixture and it has been found that, as in the case of Berar, *G. n. roseum* is the most profitable in point of yield and ginning percentage. In 1917, seed of this variety sufficient for 30,000 acres was distributed. It is suggested that an endeavour should be made by hybridisation and selection to evolve a strain of the yellow-flowered varieties, such as *G. n. malvense* and *G. n. verum*, superior to *G. n. roseum* in staple and at least equal to it in yield and ginning percentage. Meanwhile the extension of the *G. n. roseum* cotton in the Khandesh tract should be actively stimulated.

In the Kumpta-Dharwar tract, work has been carried out on the Dharwar farm chiefly with reference to the improvement of the " kumpta " cotton. Two excellent strains have been obtained, one of which, " Dharwar Selection I," is a selection from " kumpta," and the other, " kumpta cross," is a cross between two forms of " kumpta." A promising hybrid between " kumpta " and " goghari " has also been produced. The " kumpta

cross " has been distributed to growers, but it is later than either " Selection I " or the ordinary " kumpta " and possesses other disadvantages, and it has therefore now been decided to give out " Selection I " instead, as this has all the agricultural characteristics of ordinary " kumpta " to which the grower is accustomed. The Committee recommend that the work on " kumpta " should be continued, but that only one improved strain should be given out at a time. Work on the Dharwar Broach cotton has shown that this variety undergoes a steady decline in ginning percentage, and a fresh importation of seed from Broach is therefore required.

At the Gadag farm, a study has been made of American cottons, and it has been found that the Upland Georgian type is less liable to suffer from climatic effects and insect attack than the New Orleans type, and efforts are consequently being made to eliminate the latter from the Dharwar American mixture. It is recommended that these efforts should be continued and that the Upland Georgian cotton should be submitted to selection and hybridisation experiments. Cambodia cotton has been found to be seriously injured by rain after germination. Growers have allowed this variety to become mixed in their fields and the staple has undergone pronounced deterioration. The Committee suggest that no further botanical work should be conducted on this variety.

With regard to agricultural improvements in Bombay, it is recommended that the possibilities of steam and power ploughing should be further investigated, that additional seed-farms should be established in the Broach and Kumpta-Dharwar tracts, and that efforts should be made to extend the number and activity of co-operative seed unions and sale societies and to organise auction sales of seed-cotton of the improved strains in the Broach and Kumpta-Dharwar tracts.

The irrigated cotton grown in Bombay depends entirely on wells for its water supply, and there does not seem to be any prospect of its competing with such crops as rice and sugar cane under canal or tank irrigation. In the Kaira district, however, greatly increased yields of cotton have been obtained under well irrigation, and it is regarded

as very desirable that the number of wells in North Gujerat should be increased. The Committee recommend that the Government should grant loans for the purpose.

MADRAS

The average area planted with cotton in the Madras Presidency during the five years ending 1916–17 was 2,280,000 acres, and in addition there was an average area of 24,000 acres under cotton in the Native States of the Province. The percentage of the cotton area of Madras to the total cotton area of India averaged 10·2 during the same five years.

The cotton-growing regions of Madras consist of three main divisions: (1) the Deccan table-land, comprising the districts of Bellary, Kurnool, Anantapur and Cuddapah, in which the "Westerns" and "Northerns" cottons are produced; (2) the tract on which "Coconadas" is grown, comprising the districts of Guntur, Kistna, Nellore and Godavari; (3) the tract comprising the southern districts of Tinnevelly, Ramnad, Coimbatore, Madura and Trichinopoly. In this third tract, Cambodia cotton is grown on the red soils and is the most important crop in the Coimbatore district, whilst on the black soils "karunganni" and "uppam" are grown either mixed or pure.

Cotton cultivation in Madras is entirely dependent on the rainfall, except in the case of Cambodia, of which a large proportion is grown under irrigation from wells. Owing to the poorness of the soils, the yield of cotton per acre is smaller than in any other Province in India.

"Northerns" cotton is a mixture of *Gossypium herbaceum Madraspatna* and *G. indicum*. A large proportion of the cotton has a reddish tint and is regarded as of superior quality. The average length of staple of "Northerns" is ⅞ in. and its average ginning percentage 27. "Westerns" cotton consists almost entirely of *G. herbaceum*, but contains traces of *G. indicum*; it has a staple of ¾ in. and a ginning percentage 25. Cambodia and Dharwar American (*G. hirsutum*) and some *G. neglectum* are found in small areas of the "Northerns" and "Westerns" tracts.

The "Coconadas" cotton appears to contain many types, but has been stated by Gammie to consist of *G. obtusifolium Coconada* and *G. indicum* ("yerrapatti"). The greater part of this cotton has a reddish tint. The length of staple and ginning percentage of "Coconadas" apparently exhibit great variation, but the average figures are about $\frac{5}{8}$–$\frac{7}{8}$ in. and 23 respectively.

The cotton known in commerce as "Tinnevellies" consisted up to about 1907 of a mixture of "karunganni" (*G. indicum*) and "uppam" (*G. herbaceum*). The Agricultural Department have obtained two superior strains of "karunganni," with a staple of at least $\frac{7}{8}$ in. and ginning percentage 32, which are now grown on about one-half of the "Tinnevellies" tract. In other parts of the tract, "uppam" is being gradually replaced by "karunganni" but is still grown in a comparatively pure state in the Coimbatore and Trichinopoly districts, where it is known as "Salems." In this connection it may be mentioned that although the cotton bears this trade name, the area under cotton in the Salem district is quite small, amounting to only about 7,000 acres. In the Coimbatore district, "uppam" is now being replaced by Cambodia grown without irrigation. Pure "uppam" has a staple of $\frac{3}{4}$ in. and ginning percentage 25, whilst the cotton consisting of "uppam" with an admixture of "karunganni" has a staple of $\frac{3}{4}$–$\frac{7}{8}$ in. and ginning percentage 27. A perennial native cotton, known as "nadam" (*G. obtusifolium*), is grown on about 20,000 acres in the Coimbatore and Trichinopoly districts and has a staple of $\frac{3}{4}$–$\frac{7}{8}$ in. and ginning percentage 23. An inferior cotton, consisting of a mixture of two varieties of *G. neglectum* and known as "pulichai," was introduced into the Tinnevelly district about 1908, but has now been nearly exterminated.

Two exotic cottons are grown in Madras, viz. Bourbon and Cambodia. Bourbon (*G. purpurascens*) is a perennial cotton grown in the Coimbatore district on a small area of about 10,000 acres; it has a staple of at least 1 in. and ginning percentage 25. Cambodia cotton, a type of American Upland (*G. hirsutum*), was introduced from Cambodia in 1905 and is now the most important variety

grown in Madras. About one-third of the area planted with this cotton is irrigated, and gives a yield about twice as great as is produced on non-irrigated land. The length of staple varies from $\frac{5}{8}$–$\frac{7}{8}$ in. in the case of the non-irrigated crop, and from $\frac{3}{4}$–$1\frac{1}{8}$ in. in that of the irrigated crop ; the average ginning percentage is about 33.

The methods of cultivation practised in the "Northerns" and "Westerns" tracts and on the black soils of Madura, Tinnevelly and Ramnad are very good. "Northerns" and "Westerns" are always sown with a drill and are usually planted in conjunction with horse gram (*Dolichos biflorus*) or Italian millet (*Setaria italica*). The cotton is succeeded in the following year by a mixture of "juar" (*Sorghum vulgare*) and pulses. The picking, however, is badly done and the seed-cotton is marketed in a leafy and dirty condition. On the black soils of the Madura, Ramnad and Trichinopoly districts, the cotton is sown broadcast and usually follows a cereal crop. The Committee recommend that the Agricultural Department should endeavour to find a suitable leguminous crop for introduction into the rotation with cotton in the "Northerns" and "Westerns" tracts, and should investigate the possibilities of gear and steam ploughing in these areas. It is suggested that efforts should be made to establish open markets in these tracts with a view to securing an improvement in the methods of picking, and that such markets should also be established in the Coimbatore district. It is also regarded as desirable that a study should be made of suitable manures and rotations for Cambodia cotton. The Agricultural Department have established a good organisation of seed farms and seed distribution, and this could be extended with considerable advantage to the industry. In Tinnevelly, regular seed unions have been formed, and it is anticipated that these will increase in number until before long they will be sufficient to ensure a supply of pure seed to the whole tract. The Committee recommend that a similar organisation should be created as soon as possible in the other cotton-growing tracts.

Efforts have been made by the Agricultural Department to improve the "Westerns" and "Northems"

cottons. At the Hagari farm selections have been made of "Westerns," and a superior variety known as "Hagari No. 1" has been distributed. Cotton grown from selected "Northerns" seed at the Nandyal farm has proved superior to the ordinary local varieties both in yield and ginning percentage, and seed of a strain known as "Sircar No. 2" has been given out to the growers. Neither of these strains, however, has fulfilled expectations, and the Agricultural Department are now contemplating the replacement of "Hagari No. 1" by a promising new type, known as "No. 25," and the distribution in the "Northerns" tracts of a strain of *G. indicum*, known as "No. 14," which has a staple of fully 1 in. and gives a good yield per acre, but has a ginning percentage of only 25. The Committee recommend that the work on the "Westerns" and "Northerns" cotton should be continued on present lines. In the "Westerns" tracts an attempt should be made to evolve an improved type for the black soil, and to discover a type which can compete with *roseum* and other varieties of *G. neglectum* on the red soils. In the case of the "Northerns" tracts, efforts should be made to bring the ginning percentage of "No. 14" up to 27 to enable it to be substituted for the local varieties.

Selection work on Tinnevelly cotton has been conducted at the Koilpatti farm and improved types, known as "Company No. 1," "Company No. 2," and "Company No. 3," have been developed, the last two of which have proved very successful. The Committee recommend that an endeavour should be made to isolate a type intermediate between "Company No. 2" and "Company No. 3."

Comparatively little work has been done on the "Coconadas" cotton, and it is suggested that a thorough survey of the tract should be made before selection work is commenced.

With regard to Cambodia cotton, it is recommended that the Agricultural Department should aim at the production of a new type with a staple of at least 1 in. and, if possible, different types should be evolved for irrigated and non-irrigated land. As Cambodia and

"karunganni" are rapidly replacing the "uppam" cotton, it is not considered desirable that botanical work on the latter should be undertaken. Experiments which have been made in crossing Bourbon and Cambodia cottons should be carried to a definite conclusion, but no independent work should be done on Bourbon or "nadam" cotton, as their elimination is desirable owing to their liability to harbour pests.

Burma

The average area devoted to cotton in Burma during the five years ending 1916–17 was about 250,000 acres or 1·1 per cent. of the total cotton area of India. The chief cotton-growing districts are Thayetmyo, Sagaing, Lower Chindwin, Meiktila and Myingyan, which all fall within the "dry zone," the rainfall varying from 25 to 37 in. The cotton is generally grown on poor, light upland soils, but, in view of the high prices now ruling, the cultivation is being extended to black soils on which wheat is normally a more profitable crop.

With the exception of the "wa-gyi" variety and scattered plants of Cambodia and Caravonica, the only cotton grown in Burma is *Gossypium neglectum*. The "wa-gale" cotton, a mixture in which *G. n. verum burmanicum* predominates, has a length of staple varying from $\frac{1}{2}$–$\frac{3}{4}$ in. and a ginning percentage of from 28 to 33 per cent. "Wa-pyu" (*G. n. roseum avense*) and "wa-ni" (*G. n. verum Kokatia*) are occasionally met with in the "wa-gale" mixture, the latter being regarded as an impurity. The "wa-gyi" cotton, grown in Thayetmyo and Prome, is *G. obtusifolium* var. *nanking*, and has a length of staple of $\frac{3}{4}$ in. and ginning percentage 39–40. In the Northern Shan States, a cotton is grown which appears to be an Asiatic type, related to the *G. neglectum* varieties, and is said to have a length of staple of about 1 in. but a very low ginning percentage. A type of American cotton, probably Cambodia, has recently appeared in the Shan States.

Cotton is sown broadcast in Burma, but the efforts of the Agricultural Department to introduce the practice of sowing in lines has met with some success. The crop is

usually grown in rotation with "juar" or sesamum, but occasionally with wheat, and is never irrigated. The Committee recommend that when an adequate agricultural staff is available, efforts should be made to promote improved methods of cultivation, the establishment of an organisation for the distribution of pure seed and a better system of marketing.

Attempts in the past to introduce exotic varieties into Burma did not meet with any success. Cambodia cotton, however, has recently been planted in certain districts and has given promising results. Improved types of indigenous cottons have been obtained by selection and experiments have been made to obtain varieties of longer staple by crossing.

The Committee recommend that a botanical survey of the cotton tracts of Burma should be made and the types classified according to their yield and ginning percentage. Simple selection work should then be undertaken with a view to standardising the quality of the cotton. The possibilities of American cotton, especially Cambodia, should be thoroughly tested. It is suggested that a farm should be established in the Meiktila or Myingyan district for work on "wa-gale" and another in the Lower Chindwin district for experiments with cotton under well irrigation. The Allanmyo farm should carry out work on "wa-gyi" and for this purpose should be provided with a small ginning outfit.

Bihar and Orissa, Bengal and Assam

Owing to the comparatively small importance of the cotton crop in these Provinces, they are dealt with together. During the five years ending 1916–17, the average areas devoted to cotton were as follows: Bihar and Orissa, 73,000 acres; Bengal, 48,000 acres; Assam, 34,000 acres; these areas being respectively about 0·3, 0·2 and 0·2 per cent. of the total cotton area of India. In addition, an average area of 22,000 acres was planted in the Native States of Bengal.

The principal cotton grown in Bihar is *Gossypium intermedium*, which has a staple of $\frac{5}{8}$–$\frac{3}{4}$ in. in length and a

ginning percentage varying from 15 to 30, with an average which probably does not exceed 17 and is lower than that of any other cotton in India. The crop is not popular owing to its long growing season, and it is cultivated chiefly for domestic use. In Orissa, the cotton area is insignificant, no district planting as much as 5,000 acres. The cotton consists of the same mixture of *G. neglectum* varieties as is found in the Central Provinces. In the Chota Nagpur Division, the Upland Georgian type, known as "buri," is grown, which has a staple of $\frac{7}{8}$–1 in. and ginning percentage 31; the native cotton of the district is of the same type as that grown in Orissa.

In Bengal and Assam, the cotton which is known as "Comillas" is derived from *G. cernuum* and has a staple of only $\frac{3}{8}$–$\frac{1}{2}$ in., but has a high ginning percentage which averages about 43 and is sometimes as high as 50. This cotton is of a very harsh character and is commonly used for adulterating wool.

The work which has been carried out in these Provinces with exotic cottons has shown that, except in Chota Nagpur, such varieties are not adapted to the climatic conditions. In the latter Division, experiments have been made with several American varieties and certain Cawnpore selections have given promising results.

The Committee recommend that experiments should be continued with "buri" and selected American varieties in Chota Nagpur, that the botanical survey of the three Provinces should be completed, and that work should be carried out on the "Comilla" variety with a view to the improvement of its ginning percentage and, if possible, of its staple also.

Hyderabad

The average area devoted to cotton in the Hyderabad State during the five years ending 1916–17 was 3,262,000 acres or 14·7 per cent. of the total cotton area of India, including Native States.

The soil of the cotton tracts is mainly the black soil occurring in the adjoining British territory, but in the Telingana district cotton is often grown on lighter sandy soils.

The "Barsi and Nagar" cotton, which is grown in the north of the State and as far south as Gulbarga, is a mixture of the same varieties as occur in the Central Provinces and Berar, but "bani" (*G. indicum*) is present in a larger proportion and "buri" is said to take the place of the impure Upland Georgian. In the north-eastern portion of the tract, *i.e.* in the Adilabad, Nizamabad and Karimnagar districts, "buri" predominates and is grown pure over large areas, but appears to be of shorter staple than elsewhere. Further west, "bani" is now largely cultivated in the Parbhani and Nander districts. This cotton was formerly the true cotton of the Mahratwarra country, but it has suffered rapid deterioration owing to the admixture of Berar seed. The Agricultural Department, however, have devoted their energies to restoring this variety to its former purity, and it is estimated that, as the result of the distribution of pure seed, the ginning percentage has increased from 26 to 29; the staple has a length of 1 in. The "bani" of Hyderabad is now known as "gaorani." In the Raichur district and south of the Gulbarga district "Westerns" cotton is grown, and in the south-east of the Warangal district a large area is devoted to the "Coconada" variety. Cambodia cotton is now being introduced into parts of the Gulbarga district, and the Agricultural Department have established a farm for work on this variety.

The Committee recommend that a botanical survey should be made of the cotton tracts of Hyderabad, and that trials should be made to determine the comparative merits of "bani" and other varieties. It is also suggested that further experiments should be carried out with Cambodia cotton before any distribution of its seed is made on a large scale, and that botanical work on this and other varieties should be conducted in co-operation with the specialists working in British Provinces.

Baroda

The average area under cotton in the Baroda State during the five years ending 1916–17 was 725,000 acres, or 3·2 per cent. of the total cotton area of India. Of the four districts into which the State is divided, three, Kadi,

Baroda and Navsari, are in Gujerat, whilst the fourth, Amreli, is in Kathiawar.

The varieties of cotton grown are the same as those of the adjoining British territory; Kadi and Amreli fall in the "Dholleras" tract, and Baroda and Navsari in the "Broach" tract. In the Amreli district, a mixture of varieties of *G. neglectum*, known as "mathio," is grown; and in the Kadi district "wagad" and "lalio" are cultivated, the latter usually under irrigation. In the Baroda district, a mixture of "Broach" and "goghari," known as "kanvi," is grown on the black soil, whilst on the light soils the perennial variety "rozi" (*G. obtusifolium*) is cultivated in admixture with "kodra" (*Paspalum scrobiculatum*). The Navsari district is partly in the Navsari tract and partly in the Surat tract (compare page 387). The growth of the inferior "goghari" cotton has recently been extended in the southern districts of the Baroda State, just as it has in British territory. The Agricultural Department have made experiments with several American varieties, but without much success, and some work has also been done to effect an improvement in the indigenous kinds.

The Committee recommend that no further attempts should be made to introduce exotic cottons, but that the Agricultural Department should confine their efforts to the improvement of the native varieties and the production of good seed for distribution. In particular, work should be done on the "Dholleras" mixture, and endeavours should be made to maintain the purity of "wagad" and to restore "lalio" to its former degree of purity. It is suggested that the work should be conducted in co-operation with the Agricultural Department of Bombay.

Central India

During the five years ending 1916–17, the Native States of which Central India is composed had an average cotton area of 1,335,000 acres, or 6 per cent. of the total cotton area of India. This included about 450,000 acres in Indore, 380,000 acres in Gwalior, and 73,000 acres in Bhopal.

The principal cotton of Central India is the same mixture of varieties of *G. neglectum* with a small proportion of "bani" (*G. indicum*) and Upland Georgian (*G. hirsutum*) as is found in the Central Provinces and Berar. In the Nimar tract, the mixture exactly resembles that of the Central Provinces and Berar, but on the plateau the cotton contains a large proportion of *G. neglectum malvense*. The latter is an excellent cotton with length of staple $\frac{3}{4}$–$\frac{7}{8}$ in. The ginning percentage, however, is only 25, and this accounts for its partial replacement during recent years by other varieties of *G. neglectum*, and especially *G. n. roseum*; it is estimated that the *malvense* variety is not now grown pure on more than 112,000 acres and that very little of it is marketed except in an adulterated condition.

The Committee recommend that the Agricultural Department should devote their attention chiefly to selection work on *G. n. malvense* and to the establishment of an organisation to secure the marketing of the cotton in a pure state. Experiments have been made with various exotic cottons and with Leake's improved native varieties (see page 378), but definite conclusions have not yet been reached. It is suggested that the experiments with Upland Georgian and Cambodia cottons under irrigation and with Leake's varieties should be continued, and that if the work on *G. n. malvense* should prove impracticable owing to the difficulty of obtaining pure seed, efforts should be made to stimulate the cultivation of Upland Georgian and Cambodia on irrigated soils, provided that their suitability has been first established. It is also recommended that the Agricultural Department should obtain the advice and assistance of scientific officers working in British territory and that the possibilities of well irrigation should be thoroughly investigated.

Rajputana and Mysore

The average area devoted to cotton in the States of Rajputana during the five years ending 1916–17 was 372,000 acres, or 1·7 per cent. of the total cotton area of India, exclusive of an average area of 45,000 acres (0·2 per cent. of the total cotton area of India) in Ajmer-

Merwara. In the State of Mysore, the average cotton area during the same period was 115,000 acres, or 0·5 per cent. of the total cotton area of India.

In Rajputana, the cotton grown is a mixture of the same varieties as occur in the United Provinces. The crop is ginned entirely by hand, and is used for weaving goods for local consumption. Work on the improvement of the cotton does not appear to have been carried out hitherto in these States, and this must await the development of Agricultural Departments. The Committee recommend that a botanical survey of the cotton tracts should precede any such work.

In Mysore, the varieties of cotton cultivated are the same as those grown in the adjacent districts of Bombay, viz. "kumpta" and Dharwar American. Selection work on "kumpta" has been undertaken by the Agricultural Department, and it is proposed to commence similar work on the Dharwar American variety. A small area has been planted with Cambodia cotton. The Committee recommend that the work in this State should be carried out in co-operation with the Agricultural Department of Bombay and that further experiments should be made with the Cambodia variety on irrigated tracts.

THE BASSIA TREE AND ITS PRODUCTS

Of the three species of *Bassia* commonly met with in India the principal one is *B. latifolia* (Roxb.), indigenous to the forests of Central India. It is known by the vernacular names of "mowra," "mahua," "mhoura" and "mohwa." In South India and Ceylon its place is taken by *B. longifolia*, which is put to the same economic uses. The third tree is *B. butyracea* of the sub-Himalayan tract, known as the Indian butter-tree.

The seeds of these trees yield an important commercial product in the form of the valuable edible fat known as Illipé butter, largely employed by the natives as a foodstuff. Before the war the export of seeds to Europe was considerable, being mainly utilised in Germany and

Belgium for the manufacture of margarine, soap, candles, etc. Bassia kernels and fat form the subject of articles previously published in this BULLETIN (1911, **9**, 228; 1915, **13**, 342). The trade in the kernels, and the nature and uses of the fat and the residual cake and meal are also dealt with in the Imperial Institute Monograph on *Oil Seeds and Feeding Cakes* (London: John Murray, 1915).

Amongst the native population of India the chief importance of the mowra tree lies in the flowers, which are rich in sugar and highly valued as a foodstuff and as the source of a spirituous liquor. Some conception of the value put upon the flowers for these purposes by the natives is gained from the estimate made thirty-three years ago, that in the Central Provinces over 1,000,000 people used the corollas of the mowra as a regular article of food, each person consuming about 80 lb. per annum. In the Bombay Presidency they are also used for domestic consumption on a large scale and throughout India are looked upon as a valuable reserve in famine years. The flowers of *B. butyracea* are not eaten, but a syrup prepared from them is boiled down, yielding a sugar about equal in quality to date sugar.

The mowra tree sheds its leaves in February and the flowers appear in March and April, at which time the ground beneath the trees is carefully cleared.

The flowers have a thick, juicy, globe-shaped corolla of a pale cream colour, enclosed at the base in a velvety chocolate-coloured calyx. The corollas fall in the early hours of the morning and are collected by the women and children. They are spread out to dry on mats in the sun, when they wither to half their weight and develop a brownish-red colour. In some cases the flowers are collected before they drop, and in many places it is the practice to remove only the corollas, leaving the pistil to ripen to a fruit. A tree will yield 200–300 lb. of flowers in a year.

When fresh the flowers are extremely sweet with a peculiar pungent flavour and a characteristic odour. When dry the peculiar pungent flavour is less perceptible, particularly if the stamens are removed, and the flavour then resembles that of figs. The flowers are eaten either

fresh or dried, and cooked in many different ways, with sal seeds, rice, shredded coconut, or flour.

The greater portion of the crop of flowers is used for the preparation by fermentation of daru or mohwa spirit. For this purpose jars holding from 10 to 20 gallons are charged with 10 to 20 seers of dried flowers, spent-wash and water. In some cases molasses is added and may replace as much as half the quantity of the flowers. The mixture is left to ferment, which requires from 3 to 7 days according to temperature, and the liquor is then distilled from crude earthen pots. The distillate so produced ranges from 60° to 90° under proof. A second distillation is sometimes made, raising the strength to 25° under proof. Native spirit prepared in the way described has an offensive butyraceous odour and is rich in fusel oil, one sample examined by Elsworthy containing 3 per cent. of fusel oil (*Journ. Soc. Chem. Indust.*, 1887, **6**, 23). On rectification this unpleasant odour is largely removed. By the native methods 1 maund ($82\frac{2}{7}$ lb.) of dried flowers yields about 2·12 gallons of proof spirit, but in England it was found that over 6 gallons of proof spirit could be obtained from 1 cwt. of the flowers. It has been found that mowra flowers which have been kept for some months yield a better spirit than when quite fresh, but if over twelve months old they are not so well suited for distillation.

About 1888 there was a considerable export of the flowers to Marseilles for use in making a cheap brandy; but the French Government, in order to protect the home grape industry, prohibited the import.

The composition of the flowers has been investigated at different times, and the results vary considerably, particularly in respect of the quantity and nature of the sugar present. The total amount of sugar recorded in the flowers of *B. latifolia* varies from 40 to 70 per cent. The quantity of cane sugar recorded varies from 3 to 17 per cent., and that of invert sugar from 40 to 53 per cent., whilst one author has stated that the sugar is entirely invert sugar. The dried flowers of *B. longifolia* have been stated to contain about 70 per cent. of sugar. Only a small quantity of protein is present, the maximum amount recorded in either species being 7·25 per cent.

Thirty years ago attention was directed to the richness of Bassia flowers in sugar and the possibility of their being used in India as a source of sugar for export; but when it was established that except for a very slight proportion the sugar was uncrystallisable and therefore of little value except perhaps as a brewing sugar, the interest from this point of view died down. To-day, with an enormous European production of beet sugar to compete with, the probability of Bassia flowers being called upon to supply any part of the world's sugar requirements is more remote than ever.

During the war interest was centred in the production of acetone from Bassia flowers in India to supply the local demand in connection with the manufacture of munitions. The acetone was produced by the now well-known special fermentation process, and it has been alleged that the yield from the flowers of *Bassia latifolia* was one-tenth of their weight, or nearly ten times as much as is obtainable by distilling wood. The demand for acetone in India in peace times would not be large enough to justify the available supplies of flowers being entirely devoted to the manufacture of that product, but there remains the possibility of their being used for the manufacture of industrial alcohol. Derived from a forest tree, the other products of which are also of considerable economic value, they appear to represent an exceptionally cheap source. The yield of alcohol from the flowers is high compared with that from potatoes and other materials commonly used. It has been stated that about 90 gallons of 95 per cent. alcohol is obtainable from 1 ton of dried flowers.

In view of the extended use that is now being made of alcohol for power purposes it seems likely that the most profitable way of utilising the flowers would be as a source of a mixed motor spirit of the "natalite" type for local use in India. That motor spirit can be produced on a manufacturing scale in India from Bassia flowers has already been demonstrated, and it is stated that running trials with the spirit proved satisfactory.

"Natalite" is mainly a mixture of alcohol and ether and its manufacture involves not only the production of

alcohol from the flowers but of ether from the alcohol. It would be necessary to set up an extensive plant for this purpose and whether such a procedure would be payable depends largely on the cost of collecting the raw material, which in turn is dependent to a great extent on the quantity available.

According to information supplied to the Inter-Departmental Committee on Alcohol Motor-Fuel by the Director of Commerce and Industries to H.E.H. the Nizam of Hyderabad, the total cost of collecting and drying the flowers and delivering them to a factory in the zone of growth amounts to £1 10*s*. per ton. This estimate, however, refers only to Hyderabad, where the conditions are particularly favourable owing to large numbers of the tree occurring together. In regions where the tree is more scattered the cost delivered to a factory would naturally be higher, and in such cases it would probably not pay to utilise the flowers on a commercial scale, unless the tree was cultivated for the purpose.

It has been estimated that in the Hyderabad State alone there are already sufficient Bassia trees for the production of 700,000 gallons of proof spirit per annum, in addition to that necessary for the local liquor requirements.

The mowra tree appears to be decreasing in some districts. This is due partly to the fact that the dead leaves and grass under the trees are cleared away and burnt, in order to facilitate the collection of the flowers, with the result that natural regeneration is hindered. It is important therefore that attempts should be made to encourage the cultivation of the tree, for in addition to the question of the production of alcohol from the flowers, and the value of the seed as a source of oil, the flowers form a valuable food for the natives, particularly in famine years. The tree is well adapted to withstand drought, and is specially suited for planting on dry and waste lands, where little else will grow. G. M. Ryan (*Indian Forester*, 1918, **44**, 302) suggests that if the trees are planted about fifteen to twenty per acre, the junglewood growing between would afford a supply of wood for fuel. The tree takes about twenty years to produce flowers and seeds in large

quantity, but during this period the land need not be entirely unproductive if interplanting were adopted at first. Experiments conducted in Assam during the past ten years have shown that, owing to the long tap root, the Bassia seedlings do not transplant well, and therefore the seeds should be planted *in situ*.

MANGANESE ORES: IMPERIAL INSTITUTE MONOGRAPH

The monograph on this important subject, now published by Mr. John Murray in the series of Imperial Institute Monographs on Mineral Resources, has been prepared, at the request of the Mineral Resources Committee of the Imperial Institute, by Mr. A. H. Curtis, B.A., F.G.S., who during the war was attached to the staff of the Imperial Institute. The monograph consists of three chapters. Of these, the first describes the principal ores of manganese, including true manganese ores, manganiferous iron-ores, manganiferous zinc-ores, and manganiferous silver-ores, and gives a survey of their character, occurrence and uses—both metallurgical and chemical. The second chapter deals comprehensively with the sources of manganese-ore supply within the Empire, and the third with those in foreign countries. The monograph, which is illustrated with seven statistical diagrams, concludes with a bibliography of the principal publications on the subject of manganese ores.

At the outset, it is remarked that the importance of manganese in the manufacture of iron and steel is continuously increasing, that stricter demands as regards both the chemical and the physical qualities of manganese ore are being made, and that the necessity for an increased production of high-grade manganese ore has become urgent, new sources of supply being required. The hope is, therefore, expressed that the information contained in this monograph may be of practical value to companies concerned with the exploration of mineral concessions in British territory, to individual prospectors,

and to users of manganese ore throughout the Empire, especially manufacturers of iron and steel.

The manganese ore-minerals which occur in commercially valuable quantities include: (1) the oxides, especially pyrolusite, which forms the bulk of the Russian (Caucasus) manganese ores, and (2) the manganates, especially psilomelane, which is the most abundant manganese ore found in British India, and of which the ore of the Morro da Mina mine in Brazil—probably the largest manganese-ore mine in the world—mostly consists. The silicates and the carbonate of manganese are comparatively unimportant. Accounts are given of the manganiferous iron-, zinc-, and silver-ores, which are of such considerable importance to the iron and steel industries of the United States.

Manganiferous ores are shown to be widely distributed throughout the world, although it is made clear that there are only a few countries in which important deposits of true manganese ore are known. Of these, the principal are Russia (Chiaturi, Nikopol, etc.), Southern and Central India, and East-Central Brazil. The deposits occurring in these three countries are described at considerable length. Adequate accounts are also given of minor sources of true manganese ore in British and foreign countries, among the more important of which, at the present time, are the occurrences in the United States, Cuba, Canada, West Africa (Gold Coast), and Egypt (Sinai Peninsula).

Deposits of manganiferous iron-ores are also described, more particularly those in the United States. Such ores contain a highly variable proportion of iron, usually exceeding 40 per cent. In America they occur most abundantly in the Lake Superior district and the Cuyuna iron-ore district of Minnesota. In addition to these ores the manganiferous zinc-ore (franklinite) mined in New Jersey and the manganiferous silver-ores of the Rocky Mountain and Great Basin regions have for many years furnished large supplies, suitable for the production of "spiegeleisen," the lower-grade iron-manganese alloy, containing usually only about 20 per cent. of metallic manganese.

The production of manganese ore, properly so called, in the United States has until recently (that is to say,

until the later years of the war) been almost negligible, owing to the small extent and the discontinuous and scattered nature of most of the deposits in that country, and their generally low content of manganese and high content of the objectionable impurity, silica. Consequently, as regards the higher iron-manganese alloy, " ferro-manganese " (which usually contains about 80 per cent. of metallic manganese), the United States before the war was dependent on imports from Europe—chiefly England—for something like one-half of her requirements of that alloy, the remainder being produced from high-grade manganese ore imported almost entirely from British India, Russia and (in relatively small quantity) Brazil. The United States has always been the best market for the Brazilian product, and during the war practically the whole of that product went, regardless of cost, to America, the remainder of whose requirements were obtained by the intensive exploitation of her own deposits of manganese ore, and minor shipments from Cuba, Japan and other available sources of supply. During the whole period of the war no supplies of that ore reached the United States from Russia, while shipments from India were very greatly curtailed, owing to the urgent requirements of Great Britain, France and Italy.

It remains to be seen whether the Brazilian manganese-ore industry, to which so great an impetus was given during the war by the fortuitous requirements of the United States (largely to furnish munitions for the Allies), will be able to compete successfully with the Russian and Indian industries when conditions have become normal. The more important Brazilian mines are situated at so great a distance from the nearest port that railway charges are very heavy, while the arrangements for loading into ships at Rio de Janeiro have hitherto been limited and expensive. With low rates of exchange, the Brazilian producers are normally able to compete on equal terms with the Russian and Indian in the British market, but have hitherto been at a considerable disadvantage with high rates. It has, however, been demonstrated during the war that the Brazilian manganese-ore industry, even under its present handicaps, is capable of supplying the

great bulk of America's requirements of manganese ore; so that, if prices should become permanently favourable, India may find not only Russia but also Brazil an important competitor in European manganese markets when industrial conditions become more settled. It has been estimated that the Brazilian deposits of manganese ore are sufficient to supply the world's requirements for several centuries, while those of Russia are also of great size. The "life" of the Indian manganese-ore deposits, though likely to be long, cannot be closely estimated, no boring having been done with a view to determining the magnitude of the deposits.

The United Kingdom, whose domestic resources of manganese ore are negligible, has always been the best market for the Indian product, Belgium, France, and the United States following in the order given. Germany was never an important consumer of Indian manganese ore.

Prior to the war, Germany ranked as the largest buyer of the high-grade Russian (Caucasus) manganese ore, the United Kingdom, Belgium, and the United States coming next in order of importance. Her own production of that class of ore has always been unimportant, but there are a number of manganiferous iron-ore deposits in the country, and from these a considerable production of the low-grade alloy, spiegeleisen, has been made.

Accounts are contained in the monograph of the growing manganese-mining industry of Cuba and the promising deposits of manganiferous minerals in Canada, West Africa, Egypt, South Australia and elsewhere.

The uses of manganese ores are summarised under (1) Metallurgical, and (2) Chemical, and the specific uses are given in detail. The steel industry consumes at least 90 per cent. of the world's output of manganese ore proper and manganiferous iron-ores, about three-fourths of that consumption being in the production of the alloys ferro-manganese, spiegeleisen and iron-manganese silicon (silico-spiegel).

The metallurgist buys manganese ores for their content of that metal, a basis of 50 per cent. of metallic manganese being common, with an allowance for each unit (1 per cent.) above, and a penalty for each unit below that

percentage. Ores containing under 45 per cent. of metallic manganese are saleable for the production of certain iron-manganese alloys; but for the making of high-grade ferro-manganese, a minimum closely approaching 50 per cent. is desired, and the iron content should not be high. Lime is not objected to, and is sometimes paid for. Silica is penalised when it exceeds 8 per cent., and the ore should not contain more than 10 per cent. of that impurity. Phosphorus should not exceed 0·20 per cent., and may be penalised when it exceeds 0·15 per cent. If the ore is to be used for the production of ferro-manganese, 0·1 per cent. of phosphorus is a desirable maximum. Alumina should be low, while copper, lead, zinc and barium are objectionable when present in any appreciable quantities. In America, ores containing less than 40 per cent. of metallic manganese, or more than 12 per cent. of silica, or more than 0·225 per cent. of phosphorus are subject to acceptance or rejection at the buyer's option. Not only the chemical composition, but also the physical condition of the ore as delivered, is of importance to manufacturers of iron-manganese alloys, for reasons stated in the monograph. It is pointed out, however, that manganese ore is by no means exclusively employed for the production of ferro-manganese or other such alloys, a large proportion being fed direct to the furnace in the basic process of steel manufacture so extensively employed on the Continent.

The rôle of manganese, in metallurgy, is described as being chiefly the prevention of over-oxidation of steel by the reduction of small quantities of oxide in the bath, its other effects being: the addition of the requisite amount of manganese necessary in the finished steel; the hindering of the formation of blow-holes; the elimination of sulphur from the bath; the making of iron-slag fluid and easy to run off; and, incidentally, the addition of carbon to the bath. The lower iron-manganese alloy, spiegeleisen, is normally used solely in Bessemer practice; but, during the war, it was largely employed in open-hearth steel-making in the United States, as a substitute for ferro-manganese, to meet the curtailment of supplies from England.

The chemist employs high-grade manganese ores chiefly

as oxidising agents (for the making of chlorine, dry batteries, disinfectants, etc.), manganese compounds being also used as colouring materials (for glass, pottery, tiles and bricks, in calico printing and dyeing, and for certain paints), while manganese dioxide is employed as a flux in the smelting of silver- and lead-ore.

For the production of chlorine, and generally for use as oxidisers, the peroxide ($Mn O_2$) is desired by the chemist, who employs manganese ore in this connection solely for its content of oxygen. Generally, pyrolusite and psilomelane, porous and yet compact, are the manganese minerals best suited for his purposes. The most important considerations are: (1) freedom from impurities that are soluble in acid used for the decomposition of the ore, and so cause an unnecessary consumption of acid; and (2) the amount of "available" oxygen and the ease with which it can be liberated. The presence of lime in the form of carbonate is objectionable in ore for chemical purposes, and this impurity should not exceed about 2 per cent., and may be required to be entirely absent. Ferrous compounds are also objectionable, since they act as reducing agents. Phosphorus is harmless in ores used for the production of chlorine.

Various manganiferous alloys (including manganese steel) are briefly described, and mention is made of substitutes tried in Germany during the war in place of ferromanganese.

TIN ORES: IMPERIAL INSTITUTE MONOGRAPH

The monograph on tin ores in the series of Imperial Institute Monographs on Mineral Resources published by Mr. John Murray has been prepared for the Mineral Resources Committee by Mr. G. M. Davies, M.Sc. (Lond.), F.G.S., of the Scientific and Technical Department of the Imperial Institute. It is divided into three chapters, the first of which gives a general account of the ores of tin, the world's production of tin ore, the valuation of tin ore, the price of tin, the properties and uses of tin and the recovery of secondary tin. Chapters II and III contain detailed descriptions of the principal tin-ore-

producing districts in the British Empire and in foreign countries respectively. The book concludes with a list of over two hundred references to literature on tin.

Tin is to a considerable degree a British metal. Not only are the Federated Malay States by far the largest producers of tin ore in the world, but the great smelters at Singapore and Penang supply more than half the world's output of the metal. The United Kingdom also smelts large quantities of tin, chiefly from imported ore, and thus the British Empire controls the greater part of the world's supplies of both ore and metal. Besides the Malay Peninsula, the chief British producers of tin ore are Nigeria, Australia, Cornwall, South Africa and Burma, while Bolivia, the Dutch East Indies, China and Siam are the only foreign producers of much importance.

The world's output of metallic tin is estimated at 95,000 tons in 1901 and 134,000 tons in 1913, when a decline set in. The fall in price due to overproduction in 1913 continued down to the outbreak of war, and it was not till 1917 that the price began to rise seriously. In August 1918 the price of tin in London averaged £380 16*s.* 8*d.*, against £138 16*s.* 2*d.* in June 1904, but by the end of the year it had fallen to about £267 per ton. Diagrams are given, showing the annual output of ore in the principal producing countries since 1901, and the fluctuations in the price of tin. In a third diagram the total British and foreign outputs since 1901 are plotted on the same graph as the price, illustrating the close interdependence which exists between supply and price. The opinion is expressed that the price of tin is likely to remain considerably higher than it was in 1914 for some time to come.

In the section on the valuation of tin ore the returning charges made in various countries are referred to, and some account is given of the Cornish tin ticketings. The latter system, however, seems likely to be abandoned, for while this monograph was in the press the announcement was made that three of the chief Cornish mines would no longer offer parcels of ore at the ticketings, having signed contracts with the smelters for twelve months. Other mines are expected to do the same.

After the properties of tin, the uses of the metal are described. The manufacture of tin and terne plates is the most important industry based on the use of tin. These are sheets of mild steel protected from corrosion by films of tin, and of lead and tin respectively. The alloys of tin with lead, copper, antimony and other metals are of great industrial importance, including as they do pewter, solder, fusible alloys, bronze, gun metal, bearing metal, Britannia metal, type metal, and many more. Tin compounds, such as stannic and stannous chloride, are much used in the dyeing, calico-printing and silk industries, stannic oxide is used in ceramic industries, and the oxides of tin and lead form the putty powder used for polishing glass, stone and metal. Some account is given of recent investigations as to how far the use of tin in alloys may be minimised by the substitution of less expensive metals, and various processes are described for recovering tin from scrap tin-plate and from old tin cans.

Pages 17 to 74 of the monograph are devoted to an account of sources of supply of tin ore in the British Empire. This section is liberally supplied with statistical tables, showing as far as possible the output of each country by districts, and also the destination of the exports and the source of the imports of tin and ore. These tables usually give the figures for six or eight years, and show both the normal conditions prior to 1914 and the changes due to the war.

The account of the tin deposits of Cornwall and Devon is supplemented by a note on the structure of the Cornish lodes by Professor Cronshaw, of Galway. Of the five great granite intrusions with which the tin deposits are connected, the Camborne mass is stated to yield 85 per cent. of the total output in recent years, the Land's End granite 12 per cent., and the St. Austell, Bodmin Moor and Dartmoor intrusions only about 1 per cent. each.

The deposits of the Federated Malay States naturally occupy several pages of description. Perak and Selangor are the largest producers of tin ore, the output of Pahang and Negri Sembilan being much smaller. Of the Unfederated Malay States under British protection, Johore now produces upwards of 3,000 tons of ore yearly, and

Kedah, Kelantan, Perlis and Trengganu contribute small amounts. The tin-ore output of the Straits Settlements averages only 20 tons a year, the great production of metallic tin being mostly derived from ore imported from the Federated and Unfederated Malay States, Siam, Dutch East Indies, South Africa, Australia, Burma and other countries.

Under Africa, the growth of the Nigerian tin industry is described, and some account is given of the deposits of the Transvaal, Swaziland and the Cape Province.

The Australian section is necessarily a long one, on account of the large number of workable tin deposits that are known, especially in the eastern States of the Commonwealth—Queensland, New South Wales, Victoria and Tasmania. Western Australia has two considerable tin-fields, and the Northern Territory also produces the ore, South Australia being the only State that does not contribute to the Commonwealth's output. Much of the ore is smelted at Launceston, Woolwich or Irvinebank in Australia, but considerable amounts are exported to the Straits Settlements. Of the tin exported, the greater part goes to the United Kingdom, though New Zealand, the United States and other countries are also supplied.

The tin deposits in foreign countries are purposely dealt with more briefly than those within the British Empire. The statistical tables, however, are not omitted, as it is important for the British trader to know the extent of the normal requirements of a country and from what sources they have been supplied in the past. No German statistics later than 1913 are available. That country's tin-smelting industry, based largely on imported Bolivian ore, was killed, at least for a time, by the war, and as imports of the metal were also cut off, all kinds of substitutes for tin were tried.

The tin deposits of the Dutch East Indies, Siam, Indo-China and Yunnan form part of the great tin-bearing belt of which the Malayan and Burman portions are treated in the British section of the monograph. Japan has only small supplies of tin ore, and imports some 1,200 tons of tin and 25,000 tons of tin-plate each year.

Bolivia has an annual output second only to that of

the Federated Malay States, and one which is increasing while the Malay production is diminishing. Before the war the ore was exported mainly to the United Kingdom and Germany, but now increasing amounts are going to the United States, where a tin-smelting industry has been established within the last four years.

The United States are the largest consumers of tin, though they produce only trifling amounts of ore and until recently imported the whole of their requirements as metallic tin. How far the newly established tin-smelting industry will prove successful remains to be seen; it is handicapped by having to deal with the low-grade Bolivian ores, the purer ores from British sources not being available for smelting outside the British Empire. Nevertheless, large preparations have been made, and the capacity of the smelters constructed or planned by American companies is said to be 35,000 tons of metal annually. The "secondary tin" recovered from tin scrap, old cans, etc., in the United States amounted in 1916 to 17,400 tons, valued at £3,152,300.

The references to literature on tin, which conclude the monograph, are classified under countries. These are arranged as in the text, viz.: British countries in Europe, Asia, Africa, America and Australia, followed by foreign countries in those continents. An alphabetical arrangement of countries in each continent is adopted for convenience of reference.

NOTES

Paper-Making in Australia.—In view of the present shortage of paper-making materials and the large and increasing demand for paper in Australia, consideration has recently been devoted to the possibilities of creating a paper-making industry in the Commonwealth in which locally grown plants could be utilised as the raw material. A preliminary study of this question has been carried out by the Commonwealth Advisory Council of Science and Industry, and the results have been published as *Bulletin* No. 11, entitled "Paper-pulp: Possibilities of its Manufacture in Australia," by Gerald Lightfoot, M.A., Secretary to the Council (Melbourne: Government Printer, 1919.)

In Part I of this publication it is pointed out that in 1913 the imports of paper and boards into Australia amounted to about 1,700,000 cwts., of value £1,786,400, which included 1,330,000 cwts. of printing paper. At the present time there are four mills in Victoria, two of which manufacture straw-board mainly from straw and waste paper, whilst the other two make printing and wrapping papers from waste paper, jute, rags, and imported wood-pulp. In New South Wales there is one mill which manufactures wrapping papers from waste paper, jute, rags, and wood-pulp, and another which makes boards from waste paper and wood-pulp. In Queensland small quantities of paper-pulp are manufactured from hoop-pine (*Araucaria Cunninghami*) at the Queensland Pine Company's mills at Yarraman Creek, and from blady grass or lalang (*Imperata arundinacea*) and other grasses at a small mill near Cairns. There are no paper or pulp mills in any of the other States.

In Part II an account is given of the investigations which have been made hitherto on the suitability of Australian timbers for the manufacture of wood-pulp.

Reference is made to the study of certain Tasmanian timbers which was carried out in 1915 by Mr. H. E. Surface with somewhat unfavourable results (cf. this BULLETIN, 1917, **15**, 128).

At the Queensland Pine Company's mill mentioned above, a sulphate plant has been installed for the manufacture of pulp from the hoop-pine and the bunya pine (*Araucaria Bidwilli*). This is the only attempt which has been made in Australia to produce wood-pulp on a commercial scale, and unfortunately the work is carried on under considerable disadvantages. The mill at Yarraman Creek, 124 miles from Brisbane, depends for its supplies of raw material on the waste that is left in the bush and the off-cuts at the mill where the timber is sawn for constructional purposes. This raw material has to be conveyed great distances. It is not anticipated that under these conditions the Queensland Pine Company can attain any great success, but in order to stimulate the enterprise the Inter-State Commission has recommended that the rate of bounty on the market value of pulp for paper-making should be increased from 15 to 30 per cent.

It has been pointed out by Mr. N. W. Jolly, formerly Director of Forests, Queensland, that the forests of Queensland are not pure, but contain a mixture of various trees, and that for this reason any industry requiring large quantities of timber must be situated in a central position, served by several forests. The cost of the raw material

is therefore greater than in a country where pure forests occur, and in the case of the hoop-pine the position is aggravated by the fact that frequently there is no water-supply within a considerable distance of the reserve.

In the case of the hoop-pine, Mr. Jolly states that the supplies are not sufficient to meet the demand for mill timber and that their value for milling purposes precludes their utilisation for pulp manufacture. The knotty pine tops are the only Crown source from which material can be expected at present. It is estimated that about 50,000 tons of pine tops are left yearly to rot, and that about 20,000 tons might possibly be used for pulping purposes. This supply might perhaps be supplemented with logs under 40 in. in girth for which there is no market. A plant capable of treating 10,000 tons per annum would have to be erected in a central position on either the Brisbane or Mary River waters, and it is estimated that the cost of producing pulp would amount roughly to £13 per ton.

It is suggested that the candlenut tree (*Aleurites moluccana*), which grows abundantly on the Atherton table-land, where a good supply of water is available from the Barron River, might be made use of for paper-making. This tree yields a light, soft wood which is at present unmarketable. This wood might be supplemented with that of other trees which are associated with the candlenut, such as *Eloeocarpus grandis*, *Panax elegans* and *Acronychia vestata*.

The Queensland Pine Company has tested *Eucalyptus paniculata*, *Flindersia australis* and *F. oxleyana*, but these woods have proved too hard and dense for pulping. In general, hardwoods are unsuitable except in the young stage, and, in this connection, blackbutt (*Eucalyptus pilularis*) is regarded as worthy of trial. Certain other timbers have been suggested as meriting investigation, and experiments have been made with the bark of a species of *Melaleuca* which, however, was found to be quite unsuitable.

On the whole, it is considered that the success of the wood-pulp industry in Queensland is hampered by the relationship of the timber to the water-supply, the high cost of transport, the scarcity of labour, and other factors.

In New South Wales steps have been taken by the Government to ascertain the suitability of certain woods for pulp manufacture, and samples of the mountain gum (*Eucalyptus goniocalyx*) have been forwarded to Canada for treatment on a commercial scale, but the results are not yet available. Proposals have been made to utilise the soft woods of the Dorrigo districts for pulping, and

also the hardwood forests and softwood scrubs on the Clarence River. With regard to the latter district, it is stated that an abundant supply of water and cheap power would be available, but unfortunately the forests are "mixed" and the cost of procuring wood for pulping would therefore be high.

In Victoria pulp and paper were manufactured some years ago by the Australian Paper Mills Company, of Melbourne, from the filamentary waste of the Victorian mountain ash (*Eucalyptus regnans*). A study has been made of the mountain ash (*Eucalyptus melengatensis*) and the silver top (*E. Sieberiana*) which grow abundantly in Eastern Gippsland. In 1917 samples of each of these timbers were sent by the Victorian Government to Norway for practical trials. They were only tested for mechanical pulp, and it was found that the pulp was so fragile that it broke when being removed from the rollers. The results showed that the pulp from these woods was very inferior to that made from the Norwegian pine, but it was considered that it might be used as a supplementary pulp for paste-board and thick papers.

In South Australia proposals have been made to utilise the "remarkable pine" (*Pinus insignis*) for pulp-making. There are large plantations of these trees in several parts of the State, but their exploitation is hampered by transport difficulties and lack of water. It is suggested that the planting of *Pinus insignis* in suitable areas and the establishment of other soft-wood trees is worth consideration.

In Western Australia experiments have been made on the wood of young karri trees by Mr. I. H. Boas, Technical School, Perth, and have shown that the yield of pulp is satisfactory. The best results were obtained from the wood of trees about eight years old, which yielded 48 per cent. of dry pulp (expressed on the dry wood). It is considered not improbable that even mature karri timber would furnish satisfactory paper, and this might constitute a means of utilising the enormous quantities of waste karri at the Western Australian saw-mills.

The pulping qualities of the wood of certain Australian trees, grown on a plantation in Spain, have been tested by M. Mathey, Conservator of Forests, Dijon, at the School of Paper-making at Grenoble. The Casuarinas were found unsatisfactory, as they yield only 20 per cent. of dry cellulose (expressed on the dry wood). Certain eucalypts, however, when digested with caustic soda solution, yield 42 per cent. of dry cellulose which gives good paper. These results are regarded as of importance in view of Mr.

Surface's adverse report on the Tasmanian timbers, and it is considered that the wood of the young trees of some Australian species of Eucalyptus may prove satisfactory even if that of the mature trees proves to be unsuitable.

It has been reported that spruce (*Picea excelsa*) does not grow rapidly under Australian conditions, but that possibly it might be grown profitably for wood-pulp in the mountainous parts of Victoria and Tasmania. Information on this subject and on the possibilities of the Canadian poplar (*Populus canadensis*) is given in the appendix.

In Part III of the *Bulletin* the question of utilising grasses and other fibrous plants is dealt with. Tests have been made with a number of such materials by the Australian Paper Mills Co., Ltd., Melbourne. The following were found unsuitable for paper-making: button bog rush (*Schœnus sphaerocephalus*) from Tasmania, awned saw sedge (*Gahnia trifida*) from South Australia, Queensland hemp (*Sida retusa*), saltbush (*Atriplex halimus*) from Western Australia, spinifex grass (*Triodia* sp.) from Western Australia, and the inner parts of the stems of the zamia cycad (*Macrozamia spiralis*) from New South Wales.

Blady grass or lalang (*Imperata arundinacea*), one of the commonest grasses in Northern Australia, and which also occurs in Papua, Java, and the Malay Archipelago, has been examined at the Imperial Institute and found to yield a satisfactory pulp (cf. this BULLETIN, 1918, **16**, 271; 1919, **17**, 155). This grass is being employed for pulping on a small scale at Cairns, Queensland. Proposals have been made from time to time to utilise the plant for paper-making in Malaya, but as the industry has not yet been established on a commercial scale in that country, it is considered unlikely to be profitable in Australia.

Marram grass (*Ammophila arundinacea*) is commonly grown on the coastal sand-dunes of many parts of the world to check the drifting of the sand, and it is estimated that about 5,700 acres, mainly in Victoria, have been planted with this grass. Messrs. Clayton Beadle & Stevens have carried out experiments in England which show that it yields a paper of greater strength than that from esparto grass (cf. this BULLETIN, 1913, **11**, 164). The Australian Paper Mills Co., however, have reported that the knots of marram grass are not completely disintegrated in the process of digestion, and that sand and shell grit occurring in the raw material cannot be completely removed. Moreover, it is doubtful whether the grass could be collected sufficiently cheaply to render its utilisation profitable.

Prickly pear (*Opuntia* spp.) has been tested at the Imperial Institute, and it was found that it cannot be profitably converted into paper pulp (cf. this BULLETIN, 1910, **8**, 46). This result has been confirmed by Messrs. Sindall & Bacon, of London, and also by the Australian Paper Mills Company.

Bamboo grass from the Northern Territory has been investigated at the Imperial Institute with satisfactory results (cf. this BULLETIN, 1918, **16**, 273), and has also been favourably reported on by the Australian Paper Mills Company. Further information is being collected regarding the areas and localities in which this grass occurs and also as to economic conditions.

Megass or bagasse, the residual portion of the sugar-cane after the sugar has been extracted, is known to yield a suitable pulp for paper-making. It is estimated that the sugar-cane crop of Queensland yields sufficient megass to furnish about 300,000 tons of pulp per annum, but it is considered that its value as a fuel for the sugar-mills is greater than its value for paper-making.

Reference is also made to the possibility of utilising spent wattle bark from the tanneries for the manufacture of paper-pulp (cf. this BULLETIN, 1917, **15**, 496).

Various sedges, including *Cladium Preissii*, *Gahnia decomposita*, *Scirpus* sp., and *Cladium glomeratum*, have been examined by Mr. I. H. Boas, of Perth, Western Australia, to ascertain the pulping qualities for blending with karri pulp. *Gahnia decomposita*, which grows abundantly near the young karri trees, was found to be the most suitable. Paper made from a mixture of 20 per cent. of this sedge and 80 per cent. of karri wood proved very satisfactory.

In *Bulletin* No. 1, *Department of Chemistry, South Australia*, by W. A. Hargreaves, M.A., B.Sc., an account is given of the prospects of establishing a paper-making industry in South Australia (cf. this BULLETIN, 1917, **15**, 127). It is concluded that for some years to come the principal material available for paper-making in Australia will be straw, of which over 500,000 tons are produced annually within a 100-mile radius of Adelaide. The Director of the Imperial Institute, in replying to a request for his opinion on this subject, pointed out that cereal straw appears to be the only material available in South Australia in sufficiently large quantities to form the basis of a paper-making industry, and that whilst boards and packing paper could be manufactured from this material, it would be necessary to mix other higher-grade pulps with the straw pulp for making higher-grade papers. Though rags

and waste paper might serve this purpose in the preliminary stages of the industry, it was considered that early and full attention should be given to the utilisation of other local materials or to the cultivation of crops suitable for the purpose, but that only those on the spot could decide whether the planting of coniferous trees or the cultivation of esparto grass is likely to be successful. It was recommended that an expert paper technologist or a paper-making engineer should be consulted before deciding to commence the industry.

Cotton Growing in Mozambique.—In 1916 the possibilities of cotton growing in the valley of the Zambesi were investigated by Mr. John Percival, of the British Cotton Growing Association, on behalf of the Mozambique Company. The alluvial flats of the valley are flooded during the high-water season, and as the water recedes silt is deposited on the rich black soil, and thus maintains the fertility. These marshy flats, known as "dambos" or "tandos," are almost devoid of trees, but become covered with grass about 6 ft. high which forms rich pasture for cattle. The land can be easily cleared for cotton cultivation. The Nyasaland Upland type of American cotton grows well in these areas if planted late in the season, the actual date of planting depending on the amount of flooding which takes place and the subsequent condition of the soil. In any case, planting cannot be undertaken until the dry season sets in.

In addition to these swampy alluvial flats, there are extensive tracts of land of a slightly higher elevation than the flood level of the Zambesi which are capable of producing excellent crops of cotton in seasons of average rainfall, but which fail during seasons of excessive drought. It is considered that by judicious planting on the "tandos" and on the higher lands, according to the prevailing conditions, a large average yield of cotton could be obtained in all seasons, and the industry could thus be established on a sound basis.

Mr. Percival recommends (1) that cotton growing by the natives should be strongly encouraged in the populous districts adjoining the cotton soils of the "tandos," (2) that the Mozambique Company should select suitable areas, each of 500 hectares, consisting partly of "tando" and partly of elevated land not subject to flooding, and that these should be cultivated by means of native labour under a European overseer, the ploughing to be done by means of bullock power, and (3) that suitable areas of good cotton land not cultivated by natives, in Inharuca,

Inhacaranga, Ankueze, Chiramba and Tambara should be leased to European planters.

In the Chemba district, the natives have proved to be excellent cultivators and have produced good crops of cotton. As the cotton grown in the low country tends to deteriorate in fineness, length and lustre, it is considered advisable that cotton seed should be imported annually from Uganda or Nyasaland and grown specially for seed for distribution in the ensuing season.

The following quantities of seed-cotton were purchased in Chemba and Chiramba, the chief cotton areas, during 1910–1916:—

Chemba.			*Chiramba.*		
Year.	*Tons.*	*Cwts.*	Year.	*Tons.*	*Cwts.*
1910	83	13	1910	0	4
1911	101	10	1911	0	$6\frac{3}{4}$
1912	29	10	1912	0	15
1913	310	5	1913	5	0
1914	138	10	1914	15	0
1915	250	0	1915	15	0
1916	450 (estimated)		1916	32 (estimated)	

Cotton growing has now become well established as a native industry, and it was anticipated that in 1917 and 1918 the production would probably reach the following figures:

Chemba.		*Chiramba.*	
Year.	*Tons.*	Year.	*Tons.*
1917	1,000	1917	200
1918	2,000	1918	400

British-grown Flax.—In February 1918 the Empire Flax-growing Committee was appointed by the Board of Trade to investigate the question of increasing the supply of flax in the British Empire. The Committee have now issued a Report (Cmd. 281, 1919) on the "General Situation and Immediate Prospects of Supply in April 1919."

The problem of flax supply depends on (1) the supply of fibre and (2) the provision of seed, and as these two questions involve very different considerations they are treated separately in the Report.

It is estimated that the annual pre-war requirements of the United Kingdom were normally about 100,000 tons of flax, of which Ireland furnished about 10,000 tons, Belgium, France and Holland together about 10,000 tons, and Russia about 70,000–80,000 tons. The effect of the war on the foreign sources of supply was disastrous. The flax-growing districts of Belgium and

parts of Northern France were the first to be overrun by the enemy, and the collapse of Russia in 1917 resulted in the almost complete cessation of supplies from this important source. The Dutch crop was greatly reduced and the exports to the United Kingdom were very seriously diminished. The flax-growing districts of Russia are still not freely accessible, and the free export of flax from Belgium, Holland and Northern France is not likely to be resumed for some considerable time. It is therefore of great importance to the British linen industry that supplies should be obtained from other sources.

As a result of the abnormal conditions created by the war, flax-growing has been developed in England and Scotland, and the areas under cultivation in the North and South of Ireland have been largely extended. Encouraging developments have also taken place in other parts of the Empire. In view of the fact that there will probably be a prolonged shortage in the flax supply, the Committee consider that the Government support given during the war should be continued in fostering the revival of flax cultivation in the United Kingdom and in encouraging its extension throughout the Empire.

In the United Kingdom, flax growing has survived only in Ireland, and it is therefore in Ireland that the greatest development may be expected. The area devoted to flax in Ireland in 1914 was 49,000 acres, and this was increased in 1918 to 143,000 acres. Much valuable work has been done by the Irish Department of Agriculture in connection with seed selection and the cultivation and manipulation of the crop, but the work has been hampered by lack of funds. A scheme has been inaugurated by the Flax Society, Limited, with Government assistance, under which about 10,000 acres were planted in 1918, mainly in the north of Ireland. The Committee recommend that the Department of Agriculture and Technical Instruction should at once take steps to develop and extend their existing schemes for the encouragement of flax growing in Ireland, and for this purpose they should be provided with funds to enable them (1) to provide further instruction in the cultivation and handling of the crop, and to devote special attention to the new districts where instruction is most needed, (2) to continue and extend their investigations into the selection, improvement and supply of the varieties of seed best suited to Irish conditions, and other questions affecting flax growing in Ireland, (3) to make permanent provision for the training of instructors and scutchers, and (4) to grant loans for the erection of new, and for the repair and extension of exist-

ing, scutch-mills. It is considered that the work of the Flax Society should be continued for such time as may be necessary to secure its full experimental value. The Committee also recommend that two areas of 1,000 acres each should be established in the south of Ireland to test the feasibility of reviving the industry on factory lines.

In Great Britain the question of flax production has been studied by the British Flax and Hemp Growers' Society, Limited, with the aid of grants from the Development Commissioners (cf. this BULLETIN, 1913, **11**, 531; 1918, **16**, 111). In 1917 the work was taken over by the Flax Production Branch of the Board of Agriculture. In 1918 the acreage devoted to flax amounted to 13,537 acres distributed as follows: Somerset and Dorset, 3,450; Yorkshire, 3,755; Lincolnshire, 3,173; Suffolk, 1,802; and Fifeshire, 1,357 acres. In all these areas the fibre has been prepared in well-equipped, central retteries, and it has already been proved that excellent flax can be grown in many parts of the country. The chief difficulty is the supply of labour for the harvesting of the crop and it is therefore desirable that suitable mechanical appliances should be devised for pulling the flax. Several machines have already been produced for this purpose, but are apparently all still more or less in the experimental stage. The Committee recommend (1) that the efforts made under the stress of war conditions to revive flax cultivation in England and Scotland should be continued until it has been definitely proved whether it is possible to re-establish the industry on a large scale and on a sound economic basis; (2) that in the event of the results of these experiments being economically unfavourable to the continuance of the scheme, it should be considered whether it would be desirable for part of the area and of the establishment to be retained for scientific research; and (3) that research should be undertaken on the possibilities of further mechanical improvements in cultivating and handling flax.

In Canada, flax has long been grown in small quantities in the Eastern Provinces, especially Ontario. Efforts made in 1917 and 1918 to increase the area under flax in this region resulted in 13,000 acres being planted in 1918. Reference is also made in the Report to the possibility of utilising the linseed straw produced in Western Canada (cf. this BULLETIN, 1919, **17**, 439).

With reference to the cultivation of flax in British East Africa (this BULLETIN, 1911, **9**, 11; 1914, **12**, 211, 625; 1917, **15**, 125), it is stated that 5,000 acres were

planted in 1918, and that the area might be increased to 100,000 acres in ten years. The Committee consider that the results already achieved in British East Africa justify the hope that permanent success may be assured, and they recommend (1) the provision at central points of machinery for the treatment of flax, (2) the development of agricultural research and experiment in flax production in the Protectorate by such means as after suitable investigation the local Department of Agriculture may suggest, and (3) the provision of expert assistance in the preparation and grading of flax for the market.

Reference is also made in the Report to the possibilities of flax growing in other parts of the Empire, including Egypt, Nyasaland, Rhodesia, South Africa, Australia and New Zealand.

With regard to the provision of seed, the Committee were much impressed by the fact that the flax growers of the United Kingdom were entirely dependent on Russia and Holland. Various emergency measures have been adopted by the Government to overcome this difficulty, which included the organisation of purchase in Russia and Holland on Government account, the establishment of special shipping arrangements, and the introduction of considerable quantities of Japanese seed. The question of seed will, however, remain a cause of anxiety and expense until a satisfactory supply can be secured within the British Empire. In 1918 steps were taken by the War Department to induce farmers in Western Canada to undertake the cultivation of flax for seed on a large scale, and 30,000 acres were planted with Japanese seed provided by the Government. The Committee consider that this scheme should be continued until the return of normal conditions or the development of other sources of supply have placed the seed supply on a permanently satisfactory basis.

The Use of Carvacrol in the Treatment of Hookworm Disease.—Carvacrol is a constituent of several volatile oils and is closely related chemically to thymol, which is largely used as an antiseptic and in the treatment of certain diseases, such as ankylostomiasis. Carvacrol is a powerful antiseptic, and attention was drawn in this BULLETIN (1914, **12**, 599) to the possibility of using it in place of thymol, but hitherto it has not been administered internally. In order to ascertain its value as a helminthic or vermicide, a sample of carvacrol, prepared at the Imperial Institute from Cyprus origanum oil, was for-

warded in 1917 to Dr. S. T. Darling, of the International Health Board, New York, who was at that time conducting an investigation into the hookworm disease in the Fiji Islands. Unfortunately, Dr. Darling, owing to illness, was unable to make a full trial of the oil, but he tried it on several individuals and the bitter taste was so repugnant that he questioned whether it would be possible to use it in practical field work.

Dr. Darling subsequently proceeded to Brazil to conduct additional field investigations in connection with hookworm disease, and experiments were conducted with carvacrol supplied by the Imperial Institute and by Dr. McKee of Columbia University. The following account of his results is prepared from Dr. Darling's report, a copy of which has been supplied to the Imperial Institute by Dr. V. G. Heiser, Director for the East, International Health Board.

Since no data were available as to the toxic dose of carvacrol for man, the drug was not given to human cases of hookworm disease, but dogs only were used. In so far as the experiments go, the carvacrol has not proved an efficient helminthic; and it has besides, inherent properties which render its use very disagreeable, dangerous and impracticable, unless the drug can be altered or combined in some manner so as to remedy its serious defects. Dr. Darling's experience with chenopodium in the Far East went to show that when a liquid vermicide is combined in any manner its efficacy is lowered.

It was found that carvacrol is not as toxic as chenopodium. One cc., given to a dog weighing 9 kilos, seemed to produce no symptoms, except slight irritation of the stomach with a little vomiting. Two dogs died from the poisonous effect of the drug. One was a small, sickly, weak dog of 5 kilos, which died after 24 hours, following a dose of 3 cc. of carvacrol. The symptoms were: gradually increasing weakness, coldness of extremities, shallow respiration, collapse and death. There had been some vomiting and marked salivation. Autopsy showed a chronic ulceration of the stomach, but no acute lesions. The second dog, which died 1 hour after the administration of 1 cc. of carvacrol, was a nursing puppy of only 1 kilo in weight. The symptoms were the same as those of the first dog. The autopsy was negative except for the presence of intestinal parasites. A dog of 8 kilos had almost no symptoms except slight vomiting, following the administration of 2 cc. of carvacrol. Four days later 1½ cc. of chenopodium were given which produced severe symptoms, with marked dizziness, weak-

ness, deafness and collapse. These results were verified with two other dogs.

One of the most serious defects of carvacrol is that it produces an intense irritation of the mucous membranes. The breaking of the gelatine capsule of carvacrol in the mouth always resulted in great distress to the dog, with coughing, retching, profuse salivation and vomiting. In one instance the coughing continued for 24 hours, the dog being unable to eat or drink during this time. If a capsule of 1 cc. of carvacrol were to break in a child's mouth, or be bitten through, as not uncommonly happens in the administration of chenopodium, serious results might follow. Three of the workers in the laboratory placed a drop of the drug on their tongue in order to test its action on the mucous membranes. The results were very distressing. An intense burning sensation of the whole mucous membrane of the mouth and tongue is felt at once, and if the drug reaches the pharynx a spasm of the larynx at once occurs, resulting in a sensation of strangling, which is alarming. With the gasping for breath occurs intense lachrymation and flushing of the face. The disagreeable, burning sensation in the mouth and throat lasts for 1 to 2 hours according to the size of the drop.

In order to test its efficiency as a helminthic or vermicide, thirteen dogs were treated with varying amounts of carvacrol. The drug was given in gelatine capsules, in divided doses, one capsule each for 2 or 3 doses as the case might be. In some instances a second treatment was given. With the maximum dose (3 cc.), 36 per cent. of the worms present in the intestine were removed in the case of hookworms, 80 per cent. of the ascaris worms and only 3 per cent. of the tapeworms (*Dypilidium canium*). In only one case were all the hookworms removed by one treatment of 3 cc. of carvacrol. One dog was given first a treatment of 1 cc. of carvacrol and later 3 cc., but no hookworms were removed. Nevertheless 21 worms were found in the intestines on autopsy.

The general conclusion reached is that carvacrol is not very effective in the removal of either hookworms, ascaris or tapeworms, its relative efficiency compared with chenopodium being about 36 per cent. The marked irritation of the mucous membranes, produced by carvacrol, prohibits its use alone in the treatment of hookworm disease. In view of the fact that chenopodium and other agents are more effective and palatable, it would appear that the drug does not warrant further trial.

RECENT PROGRESS IN AGRICULTURE AND THE DEVELOPMENT OF NATURAL RESOURCES

In this section of the Bulletin *a summary is given of the contents of the more important papers and reports received during the preceding quarter, in so far as these relate to tropical agriculture and the utilisation of the natural resources of the Colonies, India and the Tropics generally. It must be understood that the Imperial Institute accepts no responsibility for the opinions expressed in the papers and reports summarised.*

AGRICULTURE

Foodstuffs

Cholam for Malting.—A paper on "Cholam as a Substitute for Barley in Malting Operations," by B. Viswanath, T. Lakshmana Row, B.A., and P. A. Raghunathaswami Ayyangar, Assistants to the Government Agricultural Chemist, Madras, has recently been published in the *Memoirs of the Dept. Agric. in India, Chemical Series* (1919, **5**, No. 4). An account is given of an investigation which was undertaken with a view to discovering an efficient substitute for barley from among the common South Indian cereals. The malting capacities were tested of paddy (*Oryza sativa*), cholam (*Sorghum vulgare*), ragi (*Eleusine coracana*), tenai (*Setaria italica*), maize (*Zea Mays*), and cumbu (*Pennisetum typhoideum*). The diastatic activity of paddy, cholam, and ragi was found to be greater than that of cumbu, tenai or maize, and the three latter were therefore excluded from further tests. Cholam and ragi were shown to be better than paddy for malting purposes, as they gave extracts of greater specific gravity and their diastatic activity proceeded to completion, whilst that of paddy remained incomplete. Ragi was afterwards discarded owing to the smallness of the grain and its tendency to form a felted mass in the malting trays.

The subsequent experiments were therefore confined to a comparative investigation of cholam and barley. The results indicated (1) that cholam malt extract hydrolyses soluble starch at a greater rate than barley malt extract, (2) that in the hydrolysis of starch by cholam the proportion of dextrin to sugar produced is greater than in the case of barley malt under the same conditions, and (3) that the products of starch hydrolysis by cholam malt, as by barley malt, consist largely of maltose and dextrin.

In connection with these experiments, it is of interest to recall the opinions of brewers on the possibility of using

the Sudan variety of *Sorghum vulgare*, known as "dura," as a malting grain (this BULLETIN, 1913, **11**, 37). Samples of Sudan dura were submitted by the Imperial Institute to four brewing firms, and the general opinion was expressed that the grain contained a rather high percentage of fat and was therefore not very suitable for brewing purposes; one firm, however, considered that this difficulty might perhaps be overcome. The results of trials in malting dura on a large scale in comparison with barley are recorded in this BULLETIN (1919, **17**, 22).

Limes.—An account of the position of the lime industry of Montserrat is given in the *Rep. Agric. Dept., Montserrat*, 1917–18. It has been the custom when the lime trees on a certain area show a decline to establish a new area on a different site, and in this way the total area devoted to the crop has been maintained. During the last twelve years, however, the new areas which have been planted have not produced the desired results and the future of the industry is therefore imperilled. It is often claimed by lime growers that there has been a definite change in the climatic conditions of the island, but this does not seem to afford an adequate explanation of the comparative failure to establish regular plantations during recent years. Considerable attention has been given by the Agricultural Department to the various problems involved in connection with lime cultivation and an experiment plot has been established so that careful observations may be made. As a result of the experience gained from this plot, lime growers have been advised to adopt the following measures: (1) the artificial control of scale insects on young trees by regular spraying; (2) the provision of lateral shelter in young fields by means of green-dressing plants, such as the pigeon pea; (3) the provision of more effective wind-breaks; (4) judicious manuring of the trees; and (5) in some instances, the draining of the land.

The exports of lime products from Montserrat for the calendar year 1917 were as follows: raw lime juice, 136,706 gallons; concentrated lime juice, 969 gallons; citrate of lime, 547 cwts.; pickled limes, 53 casks; lime oil (hand-pressed), 14 gallons; lime oil (distilled), 166 gallons. Assuming that 1,000 gallons of raw juice furnish ½ ton of citrate and that the concentrated juice has a strength of 10 : 1, the total exports for the year were equivalent to 200,396 gallons of raw juice. On the same basis, the exports, expressed as raw juice for the five years 1913–1917 were: 1913, 96,118 gallons; 1914, 217,355 gallons;

1915, 57,777 gallons; 1916, 166,289 gallons; 1917, 200,396 gallons. The increase in the exports of 1917 over those of the two previous years does not indicate any permanent improvement in the condition of the industry as there has been a certain overlapping of shipments of different years' produce, the amounts actually exported depending largely on the shipping facilities.

Rice.—In Madras the rice crop occupies nearly 30 per cent. of the total cultivated area. In 1914–15 the area devoted to the crop amounted to 10,875,754 acres, and the total production, based on an estimated yield of 1,800 lb. per acre, was about 9,000,000 tons. Most of the rice is either consumed locally or distributed to other parts of India. Comparatively little is sent out of the country; the total foreign trade during the five years 1912–1916 averaged only 0·7 per cent. of the estimated annual crop and nearly the whole of this went to Ceylon. The chief rice-growing districts in the Presidency are Vizagapatam, Ganjam, Kistna, Tanjore, Malabar and Godavari.

An account of "The Milling of Rice in the Madras Presidency," by L. B. Green, Assistant Director of Industries, Madras, has been issued as *Bulletin No.* 1 (1918), *New Series, Department of Industries, Madras.* A number of mills have been erected during recent years in Kistna, Tanjore and Godavari for milling and cleaning the rice, but in the other districts the rice is usually prepared by being half-boiled, then dried in the sun, and finally husked by means of a pestle and mortar. The fact that nearly the whole of the rice crop is required for local consumption has led to the milling industry being controlled entirely by Indians, European firms showing no interest in it. The lack of European control has been a great disadvantage and has resulted in the rice-mills being erected without any standard plan and being generally operated under very inefficient and uneconomical conditions. In Tanjore, rice-milling is at present scarcely more than a rural industry, and is carried on by means of small single-huller oil-engine-driven plants. Although the export trade in rice is so small and there is therefore no incentive to compete with foreign mills, it is nevertheless very desirable that the Madras mills should be efficiently equipped and adequately organised in order to ensure the production of superior rice at a reduced cost. It is therefore hoped that the crude mills of the Kistna and Godavari districts will gradually be replaced by modern plants installed under skilled supervision. In

those districts in which the primitive indigenous method of husking is still practised, it is desirable that machinery should be introduced as soon as possible, as this would not only result in an improvement in the quality of the rice but would also set free a large quantity of manual labour for more profitable employment.

Oils and Oil Seeds

Castor Seed.—A good deal of interest has been taken in the possibility of growing castor seed as a catch-crop on young rubber clearings in Malaya (*Agric. Bulletin, F.M.S.*, 1919, **7**, 83). The local variety does well, gives good returns on most soils and is comparatively free from disease, whilst seed of a good commercial variety imported from India was found to be unsuitable owing to its liability to be attacked by disease. If the price of castor seed returns to a more or less normal state it is considered questionable if the cultivation of the crop in Malaya would prove profitable ; in India the cultivation of castor seed is chiefly in the hands of native cultivators and it seems unlikely to be a suitable crop for cultivation on a large scale.

Linseed.—The possibilities of linseed production in the British Isles are, according to Eyre, distinctly promising (*Notes on Flax—VI. Oil from British-grown Linseed :* British Flax and Hemp Growers Society). Experiments have been carried on for some years past at several places. The earlier trials (*Journ. Agric. Sci.*, 1915, **7**, 120 ; cf. this Bulletin, 1916, **14**, 114) showed that of the different varieties tested La Plata seed gave the best results, and this has been confirmed since. This variety yields 10 cwts. of dressed linseed per acre on moderately poor soil, 15 cwts. on good medium land, and as much as 20 cwts. on very good land. The average oil-content of the La Plata seed grown in this country is 40 per cent. Experiments at Wye showed that the following yields of oil per acre were obtained from the different varieties of seed : La Plata 6·26 cwts. ; Steppe 5·60 cwts. ; Moroccan 5·25 cwts. ; Dutch 4·43 cwts. ; and Baltic 2·18 cwts. The English-grown seed compared favourably with the imported seed from which it was grown, being superior in size and oil-content. In one set of experiments the imported La Plata seed contained 38·45 per cent. of oil and 1,000 seeds weighed 6·108 grammes, as compared with an average of 40·39 per cent. of oil, and 8·625 grammes per 1,000 seeds in the case of samples of seed grown on four

different farms in England. In another set of samples of seed from nine farmers who had been induced to grow linseed as a farm crop the average oil-content was 40·71 per cent. and 1,000 seeds weighed 7·878 grammes; the parent seed in these cases contained 38·8 per cent. of oil and weighed 6·421 grammes per 1,000 seed. The La Plata seed when grown in successive seasons at Wye and at Thakeham has not deteriorated in oil-content; the original seed imported in 1912 contained 38·45 per cent. of oil, whilst during the years 1913–1915 the oil-content has been from 39·1 per cent. to 42·8 per cent.

The raising of good crops of linseed is stated to present no difficulty to the farmer: it does well on any good medium land; so far the best results have been obtained on the heavier kinds of loam. The best practice is to grow the linseed after a straw crop, whilst wheat does well after linseed. As linseed is not attacked by wire-worm it is an excellent crop for newly ploughed pasture and has given good crops even on comparatively roughly ploughed land. The land must be deeply worked and firm, with a shallow surface layer to cover the seed after sowing. Land in a high state of fertility is not desirable, as it tends to induce luxuriant growth without a proportional increase in yield of seed. Except on poor soil no marked increase in yield of seed is obtained by the application of artificial manures and no change has been observed in the oil-content of the seed. The seed should be sown as soon as the condition of the soil and weather permit, generally from towards the end of March to near the end of April, according to the nature of the soil. Early sowing is useful as the crop can then be harvested before the corn harvest and allows a catch-crop to be taken off the same land. Sowing is best performed by drilling, the coulters being set about 6 in. apart; a seed-barrow may be used with good results. The seed is sown at the rate of 80 lb. per acre on average soil and is buried about ½ in. below the surface of the soil. The land must be kept moderately free from weeds, the larger weeds, *e.g.*, docks and thistles, being removed by spudding.

The crop is ready for harvesting in about 100 days after sowing, when the majority of the capsules are plump and the seeds are just changing from green to pale brown. The plants continue to flower for some time and therefore ripen fruit unevenly, but the seed ripens in the stook after cutting. The seeds contain practically all the oil when harvested in the above condition, while if they are allowed to become more ripe before harvesting much seed would be lost. The crop is harvested by scythe on

small areas ; on large areas an ordinary reaping machine is satisfactory when the knives are very sharp and so adjusted as to act quickly. The sheaves should be small, so as to allow of rapid drying and are "shocked" in the field in the usual way until dry.

Threshing of linseed can be done with an ordinary threshing machine, the drum being set close and run at high speed while the straw must be carefully fed to the machine. About two-thirds of the "cavings-riddle" should be covered to prevent much of the cavings from falling through with the seed and chaff ; unbroken seed-bolls should be passed through the drum again.

Linseed straw is useful for stack-bottoms and thatching, but is too tough and rots too slowly to make good litter ; the straw from the threshing machine is somewhat tangled and broken, but if press-baled may be sold for £4–£5 per ton, though it is stated that its prospects as a paper material do not appear to be good. The chaff consists almost entirely of broken seed capsules and may be fed to stock, ewes being particularly fond of it.

In a large number of cases the cost of production appeared to be about £7 per acre and should not exceed £9 per acre. With a yield of 15 cwts. of La Plata seed at £30 per ton the seed would be worth £22 10*s.* ; the yield of straw varies from 9 to 21 cwts. per acre according to the soil and about 7½ cwts. of chaff is also obtained which has sold at £3 per ton ; the straw and chaff together may therefore be taken at £4 per acre, making the total value of the crop £26 10*s.* per acre.

The commercial value of the oil and cake obtainable from English-grown linseed has been investigated by Morrell (*loc. cit.* p. 10), three tons of seed of the 1917 crop enabling works scale trials of the oil to be made. The oil dries more rapidly and has higher iodine and hexabromide values than Calcutta oil, and may be described as a "super-Baltic" oil. Durability tests of varnishes, paints, etc., made with oil from English-grown linseed are not yet completed. The cake was equal in feeding value to the commercial linseed cake available at the time of the experiments.

From the results of these trials it is suggested that a much larger acreage should be devoted to linseed as a seed crop in the British Isles, and it is stated that there is now a certainty of producing an appreciable quantity of high-class oil in England.

Miscellaneous.—Seeds of the "Mexican buckeye," *Ungnadia speciosa*, Endl. (Nat. Ord. Sapindaceæ), grown

in the Botanic Gardens, Sydney, New South Wales, were found to contain about 45 to 50 per cent. of oil (*Journ. Soc. Chem. Indust.*, 1919, **38**, 74 R.). The seeds, which are known to be poisonous, have been shown by Cheel and Penfold to contain a cyanogenetic glucoside and probably also contain saponin. The "Mexican buckeye" is a deciduous shrub or small tree bearing fruits similar in shape and size to small chestnuts. As the plant grows readily in Australia and the seeds are easily collected, young plants have been distributed for trial cultivation.

The Chinese vegetable tallow tree (*Sapium sebiferum*) has been found to thrive in the United Provinces and the Punjab, but cultivation was abandoned, as preliminary experiment showed that extraction of the fat by mechanical means was unsatisfactory (*Ann. Rep. Bd. Sci. Advice, India*, 1917–18, p. 11). The seeds contain (1) solid fat (vegetable tallow) in the outer albuminous coating of the seed; (2) a drying oil in the kernels. The fat is usually obtained from the outer coating by bruising the seed and boiling with water, the oil from the kernels being obtained separately by subsequent treatment. It is now stated that the fat and oil can be extracted by means of solvent (trichlorethylene) and it appears that cultivation of this tree in India might prove remunerative.

The seeds of *Jatropha curcas* have long been known to be poisonous. Physiological experiments at the Institut Pasteur now show that the seeds contain at least two toxic principles (*Bulletin de l'Office colonial*, 1919, **12**, 96). One of these principles is present in the husk and the other in the kernels. The latter principle passes into the oil when the latter is extracted by means of ether. The exact chemical nature of the substances is unknown.

The recent shortage of oils has caused attention to be drawn to the oils obtainable from various seeds which are waste products of fruit-canning and similar industries. Physiological experiments (*Bulletin* 781, 1919, *U.S. Dept. Agric.*) on human subjects have shown that apricot-, cherry- and peach-kernel oils, melon,- pumpkin- and tomato-seed oils are well assimilated and possess nutritive values equal to oils commonly used for edible purposes.

Similar experiments on animal oils and fats showed that kid fat, hard-palate fat (*i.e.* the fat from the hard palate of the mouth of cattle), oleo-oil, oleo-stearin, ox-marrow and ox-tail fat, and turtle fat, in amounts equivalent to the butter normally consumed, were well assimilated and as they are already known as food-fats should prove wholesome (*Bulletin* 613, 1919, *U.S. Dept. Agric.*).

Rubber

Hevea

Uganda.—On many plantations in Uganda, especially in the more humid districts, Hevea has become the main crop, and coffee is being grown only as a catch-crop (*Ann. Rep., Dept. Agric., Uganda*, 1917–18, p. 11). The quantity of plantation rubber exported was 144,727 lb. or about double the output of the previous year; only 9,362 lb. of wild rubber were exported. The kinds of rubber other than Hevea are neglected, as Hevea is well suited to the country. It is slow in growth, but suffers little from pests and diseases. In the year under review, however, "bark-rot" disease appeared on several estates during the wet season; remedial measures were applied (cessation of tapping and application of disinfectant) and the occurrence of warm, dry weather had a marked effect in retarding the spread of the disease. Tapping results at the Botanic Gardens and at the Government Plantations were quite satisfactory, whilst two of the estates are proving the success of rubber on a larger scale.

Varieties.—A single tree in the Economic Garden, Straits Settlements, which differed widely from *Hevea brasiliensis* in having dark grey bark and in the character of the foliage and flowers, was identified as a specimen of *H. confusa* (*Gardens Bulletin, Straits Settlements*, 1919, **2**, 113). On tapping, it gave a small yield of yellow latex, which furnished a tacky rubber of poor physical character, though it contained about 95 per cent. of caoutchouc. The tree was destroyed to avoid the possibility of cross-fertilisation with neighbouring trees, but seedlings have been raised so that the species may be available if required.

Diseases.—The great importance of the necessity for extensive research in connection with fungi on rubber trees is pointed out by Baker in a short article entitled "Hevea *versus* Fungi" (*Gardens Bulletin, Straits Settlements*, 1919, **2**, 109). After calling attention to the facts that effective scientific study of the coffee rust was only commenced *after* the coffee industry in Ceylon and Java was doomed, and that thousands of acres of Florida oranges were destroyed by the citrus canker before the importance of the disease was recognised, the author insists that "every fungus growing on or in connection with rubber trees should be known and . . . thoroughly

understood," *i.e.* the life-history of all fungi appearing on Hevea, living or dead, should be clearly traced. Obviously, such investigations would entail a great deal of work, but there can be no doubt as to the great need for research on a much more extended scale than exists at present. In the course of an incomplete survey, during a recent term of service at the Botanic Gardens, Singapore, of fungi occurring in fruiting form on Hevea trees, the author discovered ten forms of fungi new to science and one new genus. It is pointed out that some, at least, may be purely saphrophytic, though nothing is really known about this.

Tapping.—The use of drip-tins in tapping has been investigated by Arens (*Archief voor Rubbercultuur*, 1919, **3**, 36). Three fields were tapped with drip-tins, and three without, for a period of ten months, the method of tapping being changed on each area every month. The results indicated no difference either in quantity or percentage of the different qualities of rubber, whether drip-tins were used or not. It is concluded, therefore, that the use of drip-tins is not advantageous and causes additional expenses for tools and labour.

Experiments on the effect of time intervals in rubber tapping by Petch (*Bulletin* 42, 1919, *Dept. Agric., Ceylon*) show that although the total quantity of rubber was greatest with most frequent tapping, only about 12 per cent. more was obtained by tapping three times a week than by tapping twice a week; the difference in the amounts of scrap rubber obtained was very small. The yield of rubber per tapping was greater in tapping twice than in tapping three times, though a single tapping per week did not give a greater yield per tapping than tapping twice a week. The percentage of rubber in the latex increased with the time interval.

Viscosity.—From the results of experiments by Ultée (*Archief voor Rubbercultuur*, 1919, **3**, 24) it is shown that the viscosity of crêpe rubber is largely dependent on the dilution of the latex at the time of coagulation; thus, rubber of almost constant viscosity may be obtained by careful mixing of the latex and adjustment of its rubber-content before coagulation. The method of drying also influences viscosity; too high a temperature, such as is likely to occur in some drying machines, produces rubber of low viscosity. Smoking sometimes causes an increase, at other times a decrease, in viscosity, but research on the influence of smoking is not yet completed. When parts

of the coagulum are prepared on different days, the viscosity of that part prepared latest is higher than that of the rubber prepared soon after coagulation. New methods of preparation often at first yield rubber of low viscosity, presumably owing to lack of skill in applying the method. The rubber from young estates is always of low viscosity (about two-thirds that of normal rubber), but the viscosity rises rapidly as tapping proceeds.

Fibres

Coir.—The *Philippine Journ. Sci.* (1918, A, **13**, 275) contains an article on the "Mechanical Extraction of Coir" by F. V. Valencia. Hitherto coconut husks have not been employed to any large extent in the Philippines for the extraction of coir, but are generally either used as fuel or are allowed to decay. It is suggested that a valuable industry might be established in the preparation of coir and its utilisation for the manufacture of brushes, door-mats, cordage, etc.

It is pointed out that in India and other tropical countries in which coir is at present produced, the industry depends largely on the very cheap labour which is available and the extraction of the fibre is carried out to a great extent by the women and children. In the Philippines, however, it is improbable that extraction by hand would be remunerative as a large amount of labour is needed to extract a small quantity of fibre which has only a low market value. The establishment of a profitable coir industry in the Philippines would therefore necessitate the installation of an efficient power-driven plant situated within easy reach of an adequate supply of husks. In view of these facts, an account is given of the various machines required and of experiments which have been carried out by the Bureau of Science, Manila, with crushing, fibre-extracting and willowing machines, in order to determine their capacity, efficiency and power consumption.

In the same issue of the *Philippine Journ. Sci.* (1918, A, **13**, 285) a report is contributed by Albert E. W. King on the "Mechanical Properties of Philippine Coir and Coir Cordage compared with Abacá (Manila Hemp)." The work of Royle, Roxburgh and Wight on the strength and durability of coir cordage is reviewed and it is pointed out that the data are very deficient and have often been misinterpreted.

It is mentioned that in the Philippines small quantities of coir are extracted by hand, either by a retting or

a beating process, but that nearly all of it is used for domestic purposes, the fibre rarely finding its way into the market.

Measurements of the length of coir fibre have shown that the average length of the retted coir filaments is 228 mm., whilst that of the machine-cleaned filaments is 245 mm. Most filaments taper and have elliptical cross-sections, whilst the finest filaments have a circular cross-section. The latter have a diameter varying from 0·152 mm. upwards, whilst filaments with coarse elliptical sections measure up to 0·939 mm. for the maximum diameter (or width) and 0·482 mm. for the minimum diameter (or thickness). Tensile tests with single filaments gave results averaging 832 kilograms per sq. cm. for the breaking strain for the retted fibre and 1,208 kilograms per sq. cm. for the machine-cleaned fibre, the tensile strength being about one-tenth of that of Manila hemp of the Government grades, F and G. The difference in the tensile strength is less marked, however, when the fibres are made into cordage, the strength of coir rope being about one-fifth of that of the Manila hemp rope of the same size. The strength of coir rope suffers a diminution of 14 to 26 per cent. on immersion in fresh water for 24 hours, whereas the strength of Manila hemp rope is but little affected by this treatment. Little additional change occurs on continued immersion in fresh water, but the strength is further decreased by the action of salt water or by exposure to the weather.

Coir cordage and coir filaments are very extensible, the elongation sometimes amounting to as much as 39 per cent. If coir rope is wetted, the extensibility is increased by about 3 per cent. The elongation of the rope is only slightly greater than that of the filaments. In the case of Manila hemp, filaments of the Government grades, F and G, give an average elongation of only 3·6 per cent., but rope made from these grades gives an elongation three or four times as great. Coir has pronounced plastic properties and no definite modulus of elasticity. In consequence of this, the shock-absorbing power of coir is relatively small, whereas Manila hemp is a highly resilient fibre and well adapted to absorb shocks.

Flax.—In the *Agric. Gazette of Canada* (1919, **6**, 225) an account is given of the progress of flax production in Canada. At the Central Farm, Ottawa, an experimental mill has been erected and equipped with machinery and retting tanks. During the past season, experimental plots of one acre each, or about 30 acres in all, were

planted in various parts of the Dominion. Flax seed was also distributed to farmers in the different Provinces on condition that they should cultivate and harvest the crop and deliver it at the nearest siding for $45 per ton. Special attention has been devoted to tank retting with both warm and cold water and efforts are being made to standardise a process for the production of fibre of good quality. Much consideration has been paid to the question of grading the flax and a system of grading and classification which has been instituted by the Experimental Farm is described. A good deal of work has been devoted to methods of cultivation, manuring and the varieties of seed, and the expenses connected with the various operations have been carefully calculated.

The area under linseed cultivation in 1918 in the west of Canada was about a million acres distributed as follows: Saskatchewan, 700,000 acres; Alberta, 230,000 acres; Manitoba, 63,000 acres. The average yield of straw was about 1¼ tons per acre or a total of 1,250,000 tons. This straw is at present burned or wasted and a new process is therefore being tried for treating it for the preparation of flax. It is estimated that the straw would yield annually sufficient fibre for the manufacture of 350,000,000 lb. of binder twine, which at 15 cents per lb. would represent $52,500,000.

Flax has been cultivated in Victoria, Australia, for many years. The planting has been carried on chiefly in Gippsland, but although encouragement has been offered to growers in the form of a bonus on the crop, the industry has not made much progress. Enough has been done, however, to show that, under suitable conditions, flax will grow well in many parts of the State and give satisfactory yields of both fibre and seed.

During the past two years several varieties of flax have been grown experimentally at the Central Research Farm, Werribee, and an account of these trials has been given in the *Journ. Agric. Victoria* (1919, **17**, 164). The results were of an encouraging character, and an effort is being made to isolate improved strains of flax by sowing the seed from specially selected plants.

In the same *Journal* (1919, **17**, 370) it is stated that during the present season 3,000 acres will be planted with flax as compared with 1,400 acres last year. The districts in which cultivation is to be undertaken include Drouin, Warragul, Dalmore, Traralgon and Sale. The Federal guarantee for the crop has been raised from £5 per ton of flax to £6, and it is anticipated that in view of this, farmers will readily take up the crop. The

Federal Government have agreed to provide £1,000 for experimental work in connection with flax growing in Australia, and the experiments are to be directed to the determination of the most suitable soil and localities for the production of both flax and linseed. The various State Departments are co-operating with the Federal Flax Industry Committee and arrangements have been made with farmers for the planting of experimental plots.

Cotton

Uganda.—In the *Ann. Rep. Dept. Agric., Uganda Protectorate*, 1917–18, an account is given of the conditions prevailing in the cotton industry. During the year, 133,530 acres were planted by native cultivators, but the yields of cotton per acre were the lowest on record. This disappointing result was due to damage caused to the early-sown cotton by prolonged rains and the subsequent occurrence of a severe and protracted drought. The greater part of the crop was sown much too late to give a normal yield even under the best conditions, as large numbers of the cotton-growing population were required for war work just at the planting season. The exports of ginned cotton amounted to 99,395 cwts. of value £537,083 and those of unginned cotton to 282 cwts. of value £548. The value of the cotton exports amounted to over 68 per cent. of that of the total exports of the Protectorate. The amount of Uganda cotton imported into India continues to increase, the imports during the year under review being 27,156 cwts. as compared with 23,116 cwts. in the previous year.

The export of cotton seed has been greatly hampered by transport difficulties and many thousands of tons were burned. The exports amounted to only 44,021 cwts. as compared with 109,213 cwts. in 1916–17.

It is now being realised by growers that it is an advantage to keep the stained cotton separate from the clean cotton. Much cotton is wasted, especially after the plants are uprooted, in spite of the fact that even cotton of poor quality well repays the work of picking.

Practically the whole of the Uganda cotton is now ginned in the country itself. There are 33 power ginneries in working order and the erection of 20 more is contemplated.

The quality of the cotton is maintained and improved by selection work conducted on the Government Plantation at Kadunguru, Bugondo, and the whole of the seed distribution is controlled by the Agricultural Department.

West Indies.—A paper on "The Improvement of the Yield of Sea Island Cotton in the West Indies by the Isolation of Pure Strains," by S. C. Harland, B.Sc., has appeared in the *West Indian Bulletin* (1919, **17**, 145). It is pointed out that the yield of Sea Island cotton depends on a large number of factors both morphological and physiological, and that any scheme of selection must aim at a type the hereditary endowment of which will interact to the best advantage with environmental conditions. It is shown that in respect of each of the morphological characters concerned with yield, a marked improvement can be effected by self-fertilisation and selection. The relative importance of lint index and lint percentage, as factors in selection work, is discussed at some length.

In the experiments carried out by Mr. Harland, the following methods were adopted. In the study of any character affecting yield, such as the weight of lint per seed, data were obtained from as many cottons as possible, and a certain number with the highest values were selected for growing in progeny rows. On the progeny rows coming to maturity, every plant was examined for the character, and a frequency array compiled. From the row possessing the highest mean value, a few of the highest were again selected to be studied in the next generation. This process is to be continued until it is clear that the upward limit of the character has been reached, *i.e.* until the progenies of all plants in the parent strain show the same means. When this stage is reached, it will be evident that the strain is pure with regard to this particular character. All the plants worked with are self-fertilised.

By working on these lines, it has been found possible to isolate a strain of Sea Island cotton with a weight of lint per boll 31 per cent. greater than that of the ordinary type grown in St. Vincent.

Another paper by S. C. Harland on "The Inheritance of Immunity to Leaf Blister Mite (*Eriophyes gossypii*, Banks) in Cotton" is published in the same number of the *West Indian Bulletin* (1919, **17**, 162). In previous work on this subject, the author has discussed the question of the immunity of certain types of cotton to the leaf blister mite and has given an account of crosses involving immune and susceptible varieties. The following facts have already been established: (1) Some varieties of cotton, such as Sea Island and Upland, are very susceptible to attack by the mite, whilst other varieties, including certain indigenous West Indian and Brazilian kinds, are completely immune. (2) In crosses between

immune and susceptible types, the first generation is attacked in varying degree depending on the particular varieties used as parents. (3) In the second generation of a cross between the immune St. Croix native variety and the susceptible Sea Island "Chance" variety, segregation occurs into immune and non-immune.

An account is now given of the results of a cross between the immune type, St. Vincent Native, and the susceptible type, Southern Cross Upland. The first generation was intermediate but tending towards the susceptible parent. In the second generation, segregation took place into immune and non-immune. In the third generation, the immune bred true, whilst the non-immune segregated into immune and non-immune. The fact that strains of cotton immune to the attacks of *Eriophyes gossypii* can be thus obtained in the third generation of crosses between immune and susceptible varieties is not only of scientific interest but is of considerable economic importance as indicating a means of producing immune strains of Sea Island cotton.

It is pointed out in the *Agric. News* (*West Indies*) (1919, **18**, 105) that the Imperial Department of Agriculture has consistently advocated a close season for cotton and that all the smaller islands interested in the cultivation of Sea Island cotton now have laws to enforce its observance. An Act has recently been passed in Barbados which orders (1) that no cotton plants or stumps shall be left growing on any land after the thirtieth day of April in any year, and that on or before the said date all cotton plants and stumps shall be dug up and buried or effectually destroyed by fire, and (2) that no cotton shall be planted on any land in the island between the first and thirty-first days of May inclusive in any year.

A review of the cotton industry of Montserrat is given in the *Rep. Agric. Dept., Montserrat*, 1917–18. The area planted in that year was 2,608 acres and the production was 409,855 lb., which is the highest on record, the average yield per acre being 157 lb. as compared with an average yield of 146·4 lb. for the last fifteen years. The season was favourable on the whole, but a severe storm of wind and rain was experienced in September which caused serious damage to large areas, particularly in the windward district. Nearly the whole area was planted with the "Heaton 9" type of cotton, which originated in a special plant selected in the Experiment Station in 1909. The Ordinance to Regulate the Planting of Cotton (1914) was not so carefully observed as usual, and in consequence on certain areas the leaf blister mite was prevalent. The

experience of past years has clearly shown that a close season is all that is required to keep this pest under reasonable control, and it is considered that additional machinery is needed to render the law more effective. The crop realised prices of 36*d.*–40*d.* per lb., with the exception of a few bales of lower quality which were sold at 33*d.* per lb.

NOTICES OF RECENT LITERATURE

The Planting, Cultivation and Expression of Coconuts, Kernels, Cacao and Edible Vegetable Oils and Seeds of Commerce: A Practical Handbook for Planters, Financiers, Scientists and Others. By H. Osman Newland. Pp. 111, Demy 8vo. (London: Charles Griffin & Co., Ltd., 1919.) Price 6*s.* net; post free, United Kingdom and abroad, 6*s.* 6*d.*

The author, in the Preface to this book, states that as a result of the publication of the Report of the Colonial Office Committee on West African Oil-seeds, there is a desire on the part of the public for further knowledge concerning oil-seed and oil-nuts. He has, therefore, "been prevailed upon to issue as a separate book the chapters on 'Ground Nuts,' 'Palm Oil and Kernels,' 'Cacao' and 'Shea Nuts,' which originally formed part of a volume on *West Africa*—in preparation for publication after the war—and, while enlarging the same, to add chapters on Coconuts and other edible oil-nuts found throughout the Empire. Special reference is made to planting, cultivation and expression." No writer, however competent, could compress into a volume of 111 pages (of which 18 are blank) existing information on all the subjects referred to. The subject of "The Coconut and its Uses" is dealt with in 14 pages, "Palm Oil and Kernels" in 20 pages, "The Ground Nut" in 10 pages, "The Shea Nut" in 5 pages, "The Cacao Bean" in 16 pages, "Soya Beans" in 5 pages, "Cotton-seed Oil" in 1 page, and "Sesame Oil" and "Hempseed" together occupy 1 page, whilst 11 pages are devoted to various minor oil-seeds of South America and West Africa.

The author has relied very largely on other books and publications for his information, but in the Introduction acknowledges his indebtedness only to publishers of books and articles written by himself, and to certain companies and others for the use of photographs. The author has made extensive use of the articles on oil-seeds which have appeared in this Bulletin. He reprints without

acknowledgment whole sections, only making slight verbal alterations such as "over" for "more," interpolating such sentences as "(Planters need, therefore, to keep a sharp look-out)," and introducing alterations in spelling, *e.g.* "codjans" for "cadjans," "grabrous" for "glabrous," and "charts" for "chests." The whole of the section on the native uses of the coconut (pp. 12–14) is taken from the article entitled "The Coconut and its Commercial Uses" (this BULLETIN, 1912, **10**, 78); the description of palm-oil machinery (pp. 30–32, and 36–37) is taken from the article on that subject (this BULLETIN, 1917, **15**, 58); the chapter on the Shea nut, except the first paragraph, consists entirely of extracts taken from this BULLETIN (1912, **10**, 284); and there are many other examples of this usage without the slightest acknowledgment.

The only reference to this BULLETIN is on p. 49, where a table is reprinted showing the yield of dried ground nuts per acre for a number of varieties. It is, however, not pointed out that these figures are not the normal or average yields for the particular varieties mentioned, but, as stated in this BULLETIN (1913, **11**, 578), merely the yields shown by experiments conducted at the Botanic Station in Montserrat.[1]

AEROPLANE TIMBERS: THEIR STRUCTURE, FORMATION, AND MECHANICAL AND COMMERCIAL PROPERTIES. By Gilbert R. Keen. Pp. x + 78, Demy 8vo. (London: W. Rider & Son, Ltd., 1919.) Price 6*s.* net; post free, United Kingdom and abroad, 6*s.* 4*d.*

Wood plays such an important part in the construction of aeroplanes that a knowledge of the structure of the timbers suitable for the purpose and the factors which determine their suitability is of first importance. The author of the present book has attempted to supply such information, and on the whole has succeeded well. The chief wood parts of an aeroplane are described, the type of wood required for each part being indicated. There are chapters dealing with the structure of wood, the testing of timber, methods of sawing logs, and stowage and seasoning, but the bulk of the book is occupied by a description of the chief woods used for aeroplanes. The hardwoods described include the different forms of ash, walnut, hickory, mahogany, poplar, and elm, and the tulip tree;

[1] Since the notice of this book was written, the author has arranged to have inserted in every copy the following announcement:

"The author desires to record his indebtedness to the Bulletin and other publications of the Imperial Institute, and to express his regret that a suitable acknowledgment was accidentally omitted from the text."

the softwoods include the various spruces and the Lawson cypress. This section is illustrated by about sixty excellent microphotographs, showing the structure of the wood as seen in transverse, radial and tangential section.

In the event of a new edition being called for, it may be suggested that the chapter on "Structure and Formation" be submitted to a competent botanist for revision, and that the results of actual tests of woods be included in that on "Mechanical Properties."

The Silk Industry and Trade. A study in the Economic Organisation of the Export Trade of Kashmir and Indian Silks, with Special Reference to their Utilisation in the British and French Markets. By Ratan C. Rawlley, M.A., M.Sc. (Econ.). Pp. xvi + 165, Demy 8vo. (London: P. S. King & Son, Ltd., 1919.) Price 10*s*. 6*d*.; post free, United Kingdom and abroad, 11*s*.

This book embodies the results of an enquiry into the organisation of the export trade in Kashmir and other Indian silks, with special reference to their utilisation in Great Britain and France, and is intended to form an introduction to a further work of the author on the Economics of the Silk Trade. The main object of the enquiry was to ascertain how far the increasing demand for silk and silk-waste in this country and in France (in common with other consuming countries) can be supplied from India. Chiefly on account of the competition of the excellent silk obtained from Japan and China, Indian raw silks no longer occupy their former position in the English market, with the result that the export trade in raw silk (and silk fabrics) from India has considerably declined during the last thirty or forty years. The decline does not imply any serious inherent defects in the local product, and there is evidence to show that with the development of sericulture on modern lines, and with an adequate trade organisation, the production of raw silk in India can be developed with commercial success. The question remains as to whether a revived Indian silk industry, after supplying the extensive local market, can offer a product likely to find acceptance in the overseas markets.

In seeking an answer to this question, the author has consulted representative firms in practically all the branches of the silk trade in this country and in France. The results of his enquiries are brought together in the three parts of which the book is composed. Part I deals with the British Silk Industry. Each section of the industry has been considered, and its requirements as

regards the kind and quality of the raw materials used in each case have been ascertained. Special interest attaches to the weaving branch of the industry and the author has discussed fully the suitability of Indian raw silks for this purpose, special attention being paid to the present defects of the Indian material. It is considered that, with the elimination of these defects, a large demand for Indian raw silks for weaving purposes would arise in this country. A similar conclusion is arrived at with regard to the important spinning industry. Owing to defects (in large part due to careless collection and packing) Indian waste silks are held in comparatively low estimation by spinners in this country, but it would appear that the commercial value of Indian wastes could be greatly enhanced if due attention were paid to their collection and packing for the market.

Part II deals with the French industry. The author shows that the situation is essentially the same as in this country: an improvement in the quality of the product would result in a demand for manufacturing purposes.

Part III deals with the factors determining the prices of the raw silk and its rate of consumption, and concludes with a chapter on the commercial organisation necessary for the development of the Indian industry. An appendix gives an interesting historical sketch of the Indian silk industry which sets out the main causes of the decline of the trade.

Productive Sheep Husbandry. By W. C. Coffey. Pp. x + 479, Demy 8vo. (Philadelphia and London: J. B. Lippincott Company, 1918.) Price 10*s.* 6*d.* net; post free, United Kingdom and abroad, 11*s.* 3*d.*

The author, who is professor of sheep husbandry in the University of Illinois, points out in his preface that at the present time a new era is commencing in the sheep history of the United States. For the first time an attempt is being made to give attention to the whole problem of mutton and wool production. Farmers are beginning to realise that successful flock husbandry is based on a careful consideration and attention to breeding, feeding, shepherding and marketing, and that the haphazard methods once practised in handling sheep can no longer be depended on to yield profits. The present book has been prepared with the object of enabling the student and sheep-raiser to comprehend the place which sheep justly deserve in the agriculture of the United States and the methods of handling which will maintain the industry in that position.

There is hardly a single phase of sheep husbandry that is not dealt with. The first part gives a brief account of the development of sheep-raising and the various methods adopted in the chief countries of the world, together with a short discussion on the problems involved in the improvement of sheep and on methods of improvement. Part II deals with the general structure and judging of sheep, and Part III with the chief breeds introduced into the United States, including all the important British breeds, the "Corriedale" of New Zealand, "American Tunis," Merinos and Karakul. Part IV is devoted to the management of the flock, and deals with the establishment of the farm flock, the care of the sheep during and after breeding, and the gathering of the wool crop. Part V deals fully with feeding, and Part VI with sheep management on the ranges in the Western States. The final part gives a description of the buildings and equipment required in sheep-raising and an account of the methods of preparing mutton on the farm.

Although written specially for readers in the United States, the book can be recommended to all concerned with the raising of sheep. It contains 262 illustrations, mainly reproduced from photographs; those illustrating the methods of handling the sheep during judging, and the various breeds, are particularly good. There are several references to literature, in the form of footnotes, but a complete bibliography would have added to the value of what is already a useful book.

Alcohol, its Production, Properties, Chemistry and Industrial Applications. By Charles Simmonds, B.Sc. Pp. xviii + 574, Med. 8vo. (London: Macmillan & Co., Ltd., 1919.) Price 21*s.* net; post free, United Kingdom, 21*s.* 9*d.*, abroad 22*s.*

The title indicates clearly the wide and important field covered in this work by the author, who is an analyst in the Government Laboratories, London. The first chapter deals briefly with the history of alcohol and fermentation, and is followed by chapters on the production of alcohol; the general chemistry of alcohols; methyl alcohol; ethyl alcohol and its occurrence and physical properties. Chapter II is of particular interest, as it gives details of the various materials which are or might be used as sources of alcohol, including many products of tropical agriculture. This chapter also deals briefly with the important problems of the production of alcohol from wood waste, and the synthetic production from acetylene, which seems

likely to become an important factor in the near future. Chapters VI and VII, dealing with the analytical chemistry of alcohol and alcoholometry respectively, will be of great value to chemists and technologists. Chapter VIII, entitled "Industrial Alcohol," describes the uses of alcohol for industrial purposes, the regulations which apply in various countries to the use of industrial alcohol and the methods for de-naturing alcohol (*i.e.* rendering it non-potable), and the methods of examination of industrial alcohol. The remainder of the book includes chapters on the value of alcohol as a source of heat, power, etc., on spirituous beverages, on the physiological effects of alcohol, and also a useful bibliography of alcohol and allied subjects.

The book covers a wide field but is clearly and concisely written and appears to be free from omissions or errors. It will be of great value to chemists, technologists and others to have this large amount of information collected so conveniently in a single volume. The paper, binding and printing are good, and compare most favourably with many recently published scientific and technical works.

A Treatise on British Mineral Oil. Foreword by Sir Boverton Redwood, Bart. Editor: J. Arthur Greene. Contributors: E. H. Cunningham-Craig, W. R. Ormandy, F. Mollwo Perkin, Andrew Campbell, A. E. Dunstan, and A. H. Seabrook. Pp. xi + 233, 8vo. (London: Chas. Griffin & Co., Ltd., 1919). Price 21*s.* net; post free, United Kingdom, 21*s.* 6*d.*, abroad 22*s.*

The U-boat operations of the enemy in the late war, largely directed against oil-tankers, showed the insecure situation of the United Kingdom with regard to oil-supply. The position was first investigated by the Institution of Petroleum Technologists, and later by the Petroleum Research Department formed under the direction of the late Sir Boverton Redwood. To the Committee of Investigation, appointed by the Department, several of the authors of this book acted as technical advisers: they and the editor are all practical scientists, each well known.

After much research work the drilling for oil in certain places, and the utilisation of our unworked oil-shales and of the canneloid deposits of our coalfields were recommended.

This book deals mainly with available materials from which oil can be produced, as well as the important ques-

tion of future domestic fuel economy in the United Kingdom, the information given being almost entirely due to the observations and investigations of the authors.

In the first section, Mr. E. H. Cunningham-Craig deals with the geological environments, theories of origin, behaviour with solvents, and distillation of oil-shales, canneloid coals, lignite and peat; also the Scottish oil-shale industry and the Kimmeridge shales of England, with their great possibilities as a source of oil fuel.

Dr. W. R. Ormandy in the second section treats mainly with the retorting of bituminous materials. He draws attention first to the present wasteful consumption of fuel in Great Britain and to the great, and now irrecoverable, quantities of low-grade coal that have already been left behind in the mines, which could have been made use of; present-day retorting in gasworks is discussed, with the necessity for Parliament to better control the quality of the gas sold; various by-product ovens, high and low temperature distillation retorts, and producers are fully described and illustrated and results of practical tests given. With the question of power production, the author considers the possibility of distributing a 300 B.T.U. gas under pressure in large systems.

In the third section of the book Dr. A. E. Dunstan deals mainly with the products from both the low- and high-temperature distillation of coals; the brown coal industry of Germany; the breaking-down of oils from shale and peat; and, finally, the utilisation of the by-products.

Mr. A. Campbell, author of "Petroleum Refining," in a fourth section deals with the refining of low-temperature distillation oils, the use of continuous working stills, the making of paraffin candles and the handling of other products.

The Midland Testing Station of the Midland Coal Products, Ltd., at East Kirby, is described by Dr. F. M. Perkin, and is the outcome of the recommendations of the various scientific bodies that have lately been at work. It will be, when completed, of great national utility. The company, amongst other things, in connection with the production of power, will find out which British coals would better be gasified to produce power gas and which distilled for the production of smokeless fuel to burn under boilers.

Mr. A. H. Seabrook, as an engineer, finally discusses the advantages which would accrue from the burning of gas from by-product plants in boilers, instead of coal.

A valuable bibliography, mainly chemical, completes

a volume which is full of valuable first-hand material, condensed by careful editing, and which should be read by all users of fuel and those interested in our national prosperity.

Geology of India. By D. N. Wadia, M.A., B.Sc. Pp. xx + 398, Med. 8vo. (London: Macmillan & Co., Ltd., 1919.) Price 18*s.* net; post free, United Kingdom, 18*s.* 6*d.*, abroad 18*s.* 10*d.*

The lack of a handy modern volume on the geology of India has been often felt and induced the author, who is a lecturer on Geology in India, to prepare this textbook. It is largely a compilation, the author acknowledging the assistance received from the voluminous records of the Geological Survey and from the personal assistance of its Director, Dr. Hayden.

The book is divided into twenty-seven chapters, each with its separate references. The first deals with the physical characteristics of the country—the mountains, the fifteen principal glaciers of the Himalayas, the drainage systems, the few dormant or extinct volcanoes, mud-volcanoes, earthquakes effects, and desert and river erosion. The second chapter deals with the general stratigraphy of India, including that of Burma and Baluchistan, and contains a complete table of the geological formations. Subsequent chapters deal in a very complete manner with the individual geological series and systems from Archæan to Recent. A further chapter gives an outline of the physiography of India as explained after the study of the geology.

A chapter of 51 pages on economic geology describes the occurrences, distribution and users of the many different metallic and non-metallic minerals, coal, petroleum and building stones, many of which occur in the extra-peninsula.

The book is well printed and is illustrated with excellent geological maps and sections and photographs illustrating the varied physiography of the country. It deals very fully with its subject.

The Mineral Deposits of South America. By B. J. Miller and T. T. Singewald, Jr. Pp. ix + 600, Med. 8vo. (London: Hill Publishing Co., Ltd., 1919.) Price 25*s.* net; post free, United Kingdom, 25*s.* 6*d.*, abroad 25*s.* 10*d.*

Considering the vastness of the subject the authors are to be congratulated on getting together such a large

amount of information, into a comparatively small space, that will be of great use to mining engineers and capitalists. The authors, who are Professors of Geology in the United States, made a special journey of observation to South America in 1915, when they largely obtained first-hand their data on Chile, Peru, Bolivia and Brazil; of the other States the work is mainly a compilation. The continent is becoming of constantly-increasing importance as a source of fresh ore-deposits, especially to North American capitalists, who have already financed some gigantic copper enterprises in Chile and Peru, which are described in the book, and practically control the platinum industry of Colombia.

The book begins with a description of the physiography of the continent and its development as deduced from a broad study of its geology. As yet there is comparatively little detailed information on economic geology available, although much work has already been done by various organisations, especially in Chile, Peru, Argentina, Uruguay and Brazil, whose efforts are often hampered through lack of funds.

A chapter in the book describes the various occurrences of metallic and non-metallic minerals, classifying them as occurring in sedimentary, in ancient crystalline (Metamorphic) or in younger igneous rocks. Further chapters severally describe the deposits of each country in detail, each giving a résumé of mineral production; the topography and general features; a map of the whole country with its mineral deposits marked; descriptions of the various mineral occurrences, often accompanied with detailed topographical maps, photographs and geological sections. Strangely there is only one vertical section of a mine in the book—that of the Morro Velho in Brazil, remarkable for its depth; a few more would have been useful and interesting: it must be remembered, however, that a large proportion of South American mines in operation are still only in the oxidised zone above water-level. A copious bibliography at the end of each chapter will be of the greatest assistance to any one wishing to make more detailed studies. Some statistical information on mineral outputs or exports in tabular form, as an appendix to the book, would greatly increase the value of a further editiou.

Mineral Resources of Georgia and Caucasia. By D. Ghambashidze, F.R.G.S. Pp. 182, Med. 8vo. (London: Geo. Allen & Unwin, Ltd., 1919.) Price 8*s.* 6*d.* net; post free, United Kingdom and abroad 9*s.*

This book is written by a delegate from the newly-formed State of Georgia, and gives recent valuable information on a little-known part of the world, which will be welcome to many. Previous to 1801, when it was annexed by Russia, Georgia was a country with a long history. During its inclusion in the Russian Empire its importance was checked and its development was put back.

There is a short description of the history and political geography and institutions of Georgia at the beginning of the book, which is followed by a geological description of the country and a map of its mineral resources. There follows a chapter on metals, in which copper mining and production are mainly dealt with. Next to manganese and petroleum, the copper industry is the most important industry in Transcaucasia. The following chapter deals with non-metals and is specially devoted to the petroleum industry, but there are also considered amongst other things the deposits of asphalt, lithographic stone and the raw materials for making a good hydraulic cement.

A chapter is devoted entirely to the important manganese industry; to this is added a number of tables of statistical information. The country is practically without coal deposits: this is compensated for partly by the existence of a large amount of water power, which could be made use of for any electro-chemical undertakings that might be started.

Much information on metal production is given in the book, which is illustrated by good photographs of the mountainous scenery.

The Analysis of Minerals and Ores of the Rarer Elements. By W. R. Schoeller and A. R. Powell. Pp. x + 239, Med. 8vo. (London: C. Griffin & Co., Ltd., 1919.) Price 16*s.* net; post free, United Kingdom and abroad 16*s.* 6*d.*

Prior to the publication of this book there was no work in English which dealt with the complete quantitative analysis of all the ores and minerals herein considered, and the analyst desiring such information had to search through numerous journals to find original communications. The present volume will therefore be particularly welcome to the analyst whose time and library facilities are limited.

The general scheme of the book is the complete analysis of the minerals containing the rarer elements, and for this purpose the authors have not only made a wide

compilation of the analytical methods available in the literature but have also drawn up numerous schemes in tabular form. The elements considered include lithium, rubidium, caesium, beryllium, radium, scandium, gallium, indium, thallium, cerium and the allied earths, titanium, zirconium, thorium, germanium, vanadium, columbium, tantalum, selenium, tellurium, molybdenum, tungsten, uranium, ruthenium, rhodium, palladium, osmium, iridium and platinum. Many of the analytical methods given are those which the authors have found to be reliable and several new processes of separation are described.

This book should prove of great service to the experienced chemist who is called upon to make an analytical examination of the rare earth minerals.

BOOKS RECEIVED

Australia Unlimited. By Edwin J. Brady. Pp. 1084 + lvi, Demy 4to. (Melbourne : George Robertson & Co. ; London : Simpkin, Marshall, Hamilton, Kent & Co., Ltd.) Price £2 2*s*. net ; post free, United Kingdom, £2 3*s*.

The Gold Coast and the War. By Sir Charles Lucas. Pp. 56, Crown 8vo. (London : Humphrey Milford, 1920.) Price 2*s*. net ; post free, United Kingdom and abroad, 2*s*. 1*d*.

Botany for Agricultural Students. By John C. Martin. Pp. x + 585, Med. 8vo. (New York : John Wiley & Sons, Inc. ; London : Chapman & Hall, Ltd., 1919.) Price 12*s*. 6*d*. net ; post free, United Kingdom, 13*s*., abroad, 13*s*. 6*d*.

Applied Economic Botany, based upon actual Agricultural and Gardening Projects. By M. T. Cook, Ph.D. Pp. xviii + 261, Demy 8vo. (Philadelphia and London : J. B. Lippincott Company, 1919.) Price 7*s*. 6*d*. net ; post free, United Kingdom, 8*s*., abroad 8*s*. 3*d*.

Forests, Woods, and Trees, in Relation to Hygiene. By A. Henry, M.A., F.L.S. Pp. xii + 314, Med. 8vo. (London : Constable & Co., Ltd., 1919.) Price 18*s*. net ; post free, United Kingdom, 18*s*. 6*d*., abroad 18*s*. 8*d*.

IDENTIFICATION OF THE ECONOMIC WOODS OF THE UNITED STATES. Including a discussion of the Structural and Physical Properties of Wood. By S. J. Record, M.A., M.F. Second edition, revised and enlarged. Pp. ix + 157, Med. 8vo. (New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1919.) Price 8*s*. 6*d*. net; post free, United Kingdom and abroad, 9*s*.

MIKROGRAPHIE DES HOLZES DER AUF JAVA VERKOMMENDEN BAUMARTEN. Unter Leitung von Dr. J. W. Moll, bearbeitet von Dr. H. H. Janssonius. Fünfte Lieferung. Pp. 337–764, Demy 8vo. (Leiden: E. J. Brill, 1918.)

ECONOMICS OF THE SILK INDUSTRY. A Study in Industrial Organisation. By R. C. Rawlley, M.A., M.Sc. (Econ.). Pp. xvi + 349, Med. 8vo. (London: P. S. King & Son, Ltd., 1919.) Price 10*s*. 6*d*. net; post free, United Kingdom, 11*s*., abroad 11*s*. 1*d*.

MINING AND MANUFACTURE OF FERTILIZING MATERIALS AND THEIR RELATION TO SOILS. By Strauss L. Lloyd. Pp. vi + 153, Crown 8vo. (New York: D. van Nostrand Company; London: Crosby Lockwood & Son, 1919.) Price 9*s*. net; post free, United Kingdom and abroad 9*s*. 4*d*.

REPORTS OF RECENT INVESTIGATIONS AT THE IMPERIAL INSTITUTE

The following summaries have been prepared from a selection of the Reports made by the Director of the Imperial Institute to the Dominion, Colonial and Indian Governments.

FIBRES FROM INDIA, AFRICA AND THE WEST INDIES—FLAX, JUTE AND HEMP SUBSTITUTES

In the following pages an account is given of the results of examination at the Imperial Institute of samples of flax, jute and jute substitutes, and various cordage fibres, which have been received in recent years from India and different parts of Africa and the West Indies.

Flax

India

Experiments carried out in Bihar, Bengal, United Provinces and Assam have shown that there are possibilities in India for the production of flax on a commercial scale (cf. this Bulletin, 1908, **6**, 9, 401 ; 1916, **14**, 613). A sample of flax grown on an estate at Kamrup, Assam, was examined in 1916. The material, which had been scutched by hand, consisted of brownish or greenish-grey fibre, of fair lustre. The fibre was gummy in parts and contained a fair proportion of "shieve," and it was also decidedly "towy." It was of fairly good strength and varied in length from 1 ft. 6 in. to 2 ft. 9 in., being mostly about 2 ft.

The sample was examined with the following results, compared with those given by a sample of flax from

the East Africa Protectorate and a standard Belgian flax:

		Present sample.	Flax from the East Africa Protectorate.	Standard Belgian flax.
		Per cent.	*Per cent.*	*Per cent.*
Moisture		10·5	9·3	8·7
Calculated on the dry fibre.	Ash	1·4	1·1	0·9
	α-Hydrolysis, loss	18·4	9·4	11·0
	β-Hydrolysis, loss	29·2	18·3	19·2
	Acid purification, loss	6·9	2·2	3·9
	Loss on washing in water	3·9	—	—
	Cellulose	72·4	85·0	84·5
	Fat and wax	3·6	—	—
Length of ultimate fibres		0·17 to 2·3 in.	0·2 to 3·4 in.	—
Diameter of ultimate fibres		0·0003 to 0·0007 in.	0·0003 to 0·0010 in.	—

The flax was described by a firm of merchants in London as a good strong medium-quality warp flax, suitable for the use of spinners in Ireland, and comparing favourably with the medium qualities formerly received from Belgium. They valued the material at £150 per ton (December 1916), under war conditions.

Judging from the high figures for loss on hydrolysis and acid purification, and the low proportion of cellulose, this flax had probably been insufficiently retted and cleaned.

The firm who valued the sample stated that the ends of the flax were very uneven, and should have been better " squared " before scutching. As stated above, however, they regarded the fibre as of medium quality, and readily saleable under the conditions then existing, when all qualities of flax were scarce and extremely dear.

Egypt

As stated in a note published in this Bulletin (1917, **15**, 107), flax was at one time an important crop in Egypt, but owing to the establishment of the cotton industry on a commercial scale, the area devoted to flax underwent great reduction. During the war, when there was a great shortage of the fibre, the flax industry revived to some extent, the area planted in 1915–16 being 1,472 acres, as compared with 940 acres in 1913–14.

Experiments with different varieties of flax have been made at the Government Farm, Guemmeiza, and a sample

of retted flax stalks, grown from Egyptian seed, was received at the Imperial Institute in January 1917 (*loc. cit.*). Later in the same year four samples of unretted flax straw grown at Guemmeiza were received. These represented four different varieties, viz. (1) "Normandy," of which about 5,000 feddans or Egyptian acres (1 feddan = 1·038 English acres) were planted in 1917, (2) "Pskoff," (3) "Grosse Graine," grown for seed, and (4) "Beladi," an indigenous variety. The "Pskoff" and "Grosse Graine" varieties were only grown on a small scale, and no figures as to the yield are available. In the case of the other varieties the yields of seed and straw per Egyptian acre were as follows:

	Seed.	Straw.	
	Bushels.	*Tons.*	*Cwts.*
"Normandy" .	15·50	1	14
"Beladi" . .	21·75	1	6

The straw was scutched by native methods, and gave the following yields of flax and tow:

	Flax.		Tow.	
	Per cent.	*Per Eg. acre.*	*Per cent.*	*Per Eg. acre.*
"Normandy" .	10·65	404 *lb.*	8	303 *lb.*
"Beladi" . .	10·45	303 *lb.*	7·9	229 *lb.*

The samples of flax straw received were as follows:

(1) "*Normandy*" *variety.*—This sample consisted of straight stems from 32 to 40 in. in length, free from side branches, but of somewhat uneven diameter, varying from very fine to coarse. Some green unripe straw was also present.

(2) "*Pskoff*" *variety.*—This consisted of golden-yellow stems, free from side branches and measuring from 34 to 41 in. in length. The stems were of medium thickness, and did not vary to any appreciable extent.

(3) "*Grosse graine*" *variety.*—These stems were greenish-yellow, free from side branches and measured from 36 to 42 in. in length. The straw was of large and even diameter. Some of the stems were green and apparently not fully ripe.

(4) "*Beladi*" *variety.*—This consisted of fine brownish-yellow stems of even diameter, measuring from 26 to 31 in. in length and free from side branches.

All four samples were practically free from "burns," that is, from brown patches due to fungoid attack, which are liable to cause the fibre to break at the point of infection.

Experiments were made at the Imperial Institute in order to ascertain the yields of fibre obtainable from the four samples of straw, by submitting them (1) to mild chemical treatment by boiling with dilute caustic soda for a short time, followed by the drying and crushing of the stems and removal of the shieve by hand; and (2) by retting in warm water and subsequently removing the shieve by hand. The results obtained are given in the following table, together with (3) the yields obtained on scutching the unretted straw by a firm of flax spinners who were consulted by the Imperial Institute in connection with the investigation.

	"Normandy."	"Pskoff."	"Grosse Graine."	"Beladi."
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
(1) Yield (including tow) by boiling with dilute caustic soda	(*a*) 23·0	21·5	19·9	21·0
	(*b*) 19·2	16·4	—	—
(2) Yield (including tow) by retting	(*a*) 18·5	19·0	19·5	18·0
	(*b*) 21·6	18·8	20·8	20·0
(3) Yield (not including tow) by scutching the unretted straw	22·9	17·8	19·2	13·6

The yields of fibre obtained by the laboratory methods (1) and (2) are not very concordant, probably largely owing to the difficulty of obtaining small samples of straw really representative of the bulk and to unavoidable losses when working with small quantities of fibre. The results show, however, that there is no very great difference between the best yields of fibre obtained by these methods from the four varieties of straw. It will also be seen that the yields obtained in the case of the "Normandy" and "Beladi" varieties are in all cases higher than those obtained in Egypt by native scutching methods (*cf.* p. 457).

The appearance of the fibre obtained by scutching the unretted straw (method 3) was not satisfactory and indicated that an accurate estimate of the yield of fibre could not be obtained in this way.

On the whole it seems probable that three of the four varieties of flax, viz. "Normandy," "Pskoff" and "Grosse Graine," should give satisfactory yields of fibre on a com-

mercial scale. The "Beladi" straw is short and thin, and the separation of the fibre is very troublesome; on a large scale therefore the yield of fibre from this variety might be low and the percentage of tow rather large.

A firm of flax spinners in Ireland, who examined the samples, stated that although flax is not usually sold as straw, it has been sold recently in this form to a limited extent at an abnormally high price. They considered that if saleable in this way the "Normandy" straw might realise £20 to £22 per ton in the United Kingdom under present conditions, and the "Beladi" straw possibly £12 to £14 per ton, the other two varieties being intermediate in value.

In continuation of the foregoing investigation four small samples of flax, representing the above four varieties, and scutched by the native method, were forwarded in February 1918. Corresponding samples of tow were also received. The samples of flax were as follows:

No. 1. "*Normandy.*"—This was soft, fine, lustrous fibre, of brownish-grey colour, well cleaned and free from appreciable quantities of shieve. The strength was rather poor. The fibres measured up to 36 in., but were mostly about 20 in. in length.

No. 2. "*Pskoff.*"—The fibre was fairly soft and lustrous, of brownish-grey colour, and well cleaned, but not quite so fine as sample No. 1 ("Normandy" variety). The strength was fair. The fibres measured up to 40 in., but were mostly about 24 in. in length.

No. 3. "*Grosse Graine.*"—The fibre was fairly lustrous, of brownish-grey colour, rather coarser and harsher than samples No. 1 and 2 ("Normandy" and "Pskoff" varieties) and not quite so well cleaned, more shieve being present. The strength was superior to that of samples 1, 2 and 4. The fibres measured up to 35 in. and were mostly about 20 in. in length.

No. 4. "*Beladi.*"—This fibre was soft, fine and lustrous, of brownish-grey colour and on the whole well cleaned although more shieve was present than in samples 1, 2 and 3. The strength was fair. The fibres measured up to 30 in., but were mostly from 17 to 20 in. in length.

The four samples of flax all appeared to be of satisfactory quality, though they were rather lacking in strength. The "Normandy" variety was the best, whilst the "Pskoff" and "Grosse Graine" samples were distinctly harsher and coarser than the other two varieties.

A firm of merchants in London to whom samples were submitted regarded the "Normandy" flax as considerably superior to the other three samples and stated that it was about equal in quality to flax now being produced in the East Africa Protectorate. They added that the remaining samples consisted of rather coarser fibre which would be less valuable for textile purposes, but would nevertheless be quite acceptable to spinners in the United Kingdom.

This firm valued the samples of flax as follows (September 1918):

Variety.	Value per ton. £
"Normandy" . . .	200–220
"Pskoff"	170–180
"Grosse Graine" . .	150–160
"Beladi". . . .	170

Samples of the flax and tow were also submitted to a firm of flax spinners in Ireland, who stated that it was difficult to assign values to such small samples, but that they might be regarded as worth about the following prices (July 1918):

Variety.	Value of Flax. *Per ton.* £	Value of Tow. *Per ton.* £
"Normandy" . . .	200	100
"Pskoff"	170	95
"Grosse Graine" . .	140	60
"Beladi"	190	80

The firm stated that the samples had an unusual odour and were not in the condition in which flax is usually met with on the market. They inclined to the opinion that the straw had perhaps been pulled when too ripe or had been steeped in warmer water than is desirable.

The results of the examination and valuation of the samples indicate that the "Normandy" flax is the best of the four varieties, thus confirming the conclusion drawn from the examination of the four samples of flax straw (see

p. 460). Flax represented by all the samples would be saleable in the United Kingdom at good prices under present conditions.

A further sample of flax grown from "Normandy" seed in Egypt, and taken direct from the scutching machine at the Benha Flax Works near Cairo, was forwarded in February 1919. It was stated that the sample represented the flax which was then being exported from Egypt.

The fibre was of greyish colour, of good lustre and practically free from shieve, but was of rather coarse appearance. The material had been somewhat unevenly prepared and contained some weak, tangled fibre, especially at the ends.

The fibre was of fairly good but rather irregular strength and was superior in this respect to the previous sample of "Normandy" flax (see p. 459). The length varied up to 3 ft. 6 in., being mostly about 2 ft.

A firm of merchants who examined the fibre described the flax as of fair strength and good spinning quality, but irregular in length and "taily" at the ends. They valued the sample at about £260 per ton in London (May 1919).

A firm of spinners also considered the sample to be of good quality and stated that it was the best Egyptian flax they had seen. As they had had no experience of the way in which Egyptian flax behaves when spun alone they were not able to assign a definite value to the sample, but they estimated that it would be worth from £250 to £300 per ton in the United Kingdom (May 1919).

This "Normandy" flax from the Benha Works was of good quality, and would be readily saleable in the United Kingdom if offered in commercial quantities, but it could be still further improved by more care in preparation.

The merchants to whom the sample was submitted stated that there has been considerable irregularity in the quality of the flax received from Egypt, and that some of it has been found objectionable by spinners, owing to having been retted in polluted water. These points should receive attention in connection with the extension of flax production in Egypt.

Sunn Hemp as a Flax Substitute

The fibre known in India as "sunn" or "san" hemp, and on the English markets as Bombay or Deccan hemp, is obtained from the stems of *Crotalaria juncea*, by a retting process similar to that used in the case of jute. Samples prepared by the ordinary methods in Bengal were examined at the Imperial Institute some years ago (see this Bulletin, 1910, **8**, 121). Considerable quantities of the fibre are imported into the United Kingdom and serve as a substitute for European hemp for cordage manufacture.

On account of the shortage of flax in India during the war, the Fibre Expert to the Government of Bengal advocated the use of suitably prepared sunn hemp as a substitute for that fibre in the manufacture of canvas. Samples of sunn hemp were prepared by a special process and the general opinion expressed was that the softened fibre is capable of being made into a much better class of canvas than jute. According to the *Indian Munitions Board Industrial Handbook*, 1919, p. 368, two large commercial concerns have taken up the matter, and one of these has arranged for the importation of flax-spinning machinery, which is to be used for the working of sunn hemp, and in part for flax when it becomes available. In addition to canvas it is believed that sunn hemp could be used for other coarse materials, such as hose-pipe fabric and belting, and possibly also for shoe-maker's thread.

Samples of sunn hemp specially prepared by the Fibre Expert to the Government of Bengal were submitted to the Imperial Institute in May 1918.

The following report gives the results of their examination:

"*A.—Megna Sann, after treatment.*"—A greyish-buff, lustrous fibre, well prepared on the whole, and much softer than commercial Sunn hemp. The sample was practically free from woody matter, but a small amount of soft, fluffy, tangled fibre was present. The fibres measured up to 4½ ft. in length, but were mostly from 2½ to 3 ft. The strength was variable, but fair on the whole.

"*B.—Megna Sann, after second treatment.*"—A soft, lustrous, pale buff-coloured fibre, containing a considerable amount of very short, fine, almost white, fluffy fibre

and a little woody matter. The fibres measured up to 5 ft. in length, but were mostly from 3 to 3½ ft. The strength was poor.

"*C.—Megna Sann, slightly different treatment from A.*"—This fibre was very similar to sample A, but was of rather poor strength.

"*D.—Jubbelpore Hemp, one treatment.*"—This fibre was similar in general character to samples A and C, but was of slightly darker colour and contained more gum and woody matter. The fibres measured up to 5 ft. in length, but were mostly about 3 ft. The strength was fair.

"*E.—Megna Sann, perhaps rather over-treated, but hackled after treatment.*"—Soft, rather weak, pale buff fibre, intermediate in character between samples A and B, but containing much less short fluffy fibre than B. The material had not the appearance of hackled fibre. The fibres measured up to 4½ ft. in length, but were mostly from 3 to 3½ ft.

"*F.*"—Fine, rather weak, fairly soft, lustrous fibre, of pale greyish-buff colour and containing a considerable amount of very short, soft, fluffy fibre and a fair amount of woody matter. The fibres measured up to 4½ ft. in length, but were mostly about 3 ft.

"*G.*"—Very short, fine, soft, fluffy, tangled fibre of poor strength, resembling tow, and of greyish-buff tint. The fibres measured from 8 to 20 in., but were mostly from 8 to 12 in.

The samples were all much softer than ordinary Sunn hemp, but not so strong, so that the softness had apparently been secured at the expense of strength. Some of the samples, such as "B" and "F," contained considerable quantities of soft, weak, pale, fluffy fibre, composed of strands which were partially disintegrated into ultimate fibres.

The samples were submitted to chemical examination at the Imperial Institute with the following results:

		A.	B.	C.	D.	E.	F.	G.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture		7·0	6·7	6·9	5·9	6·2	7·9	6·2
Calculated on the dry fibre.	Ash	0·4	0·5	0·5	0·1	0·2	0·4	0·7
	α-Hydrolysis, loss	3·2	2·5	1·4	1·1	0·4	2·7	1·5
	β-Hydrolysis, loss	6·0	5·1	2·7	1·5	0·8	5·0	2·8
	Acid purification, loss	1·3	0·8	1·0	1·3	2·9	1·5	2·4
	Loss on washing in water	1·0	0·6	0·6	0·6	nil	1·0	1·2
	Cellulose	93·5	93·2	93·2	94·5	94·4	92·5	94·9

The corresponding figures obtained for eight samples of ordinary Sunn hemp from India, previously examined at the Imperial Institute, are given below for comparison with those in the above table :

	Commercial Sunn hemp. (1)	Commercial Sunn hemp. (2)	Sunn hemp from Burma.	Sunn hemp from Calcutta.	Sunn hemp from Eastern Bengal and Assam. (1)	(2)	(3)	(4)
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	8·3	7·4	9·8	9·4	8·2	8·3	8·0	9·5
Calculated on the dry fibre. Ash	0·3	0·6	3·1	0·6	0·3	0·3	0·3	0·4
α-Hydrolysis, loss	8·2	7·9	9·2	10·5	6·7	6·3	7·5	8·0
β-Hydrolysis, loss	21·7	16·9	15·8	14·0	15·7	15·7	16·0	17·3
Acid purification, loss	6·0	2·1	3·7	1·6	1·4	1·0	1·0	2·0
Loss on washing in water	1·2	2·0	—	—	—	—	—	—
Cellulose	87·0	84·5	87·5	90·8	87·6	88·8	87·9	87·6

It is obvious from these results that the treated fibres have undergone marked changes in character and composition. The losses suffered on hydrolysis are much lower and the percentage of cellulose higher than in the case of ordinary Sunn hemp, and it is therefore evident that the treatment to which the samples had been subjected had removed constituents soluble in hot dilute alkali. No information was furnished to the Imperial Institute as to the methods of treatment employed in the preparation of the fibres, but the facts mentioned above and the presence of traces of alkali in the samples indicate that the fibre had probably been soaked or heated in alkaline solutions.

As a general rule the use of chemicals in the preparation of fibres should be avoided as far as possible, as such treatment is liable to impair the strength of the fibre and cause the strands to become partially disintegrated into short ultimate fibres, leading to waste in manufacture. Both these defects are exhibited by the present samples of Sunn hemp.

Jute

True jute is obtained almost entirely from India, and is the product of two species of *Corchorus*, viz. *C. capsularis*, and *C. olitorius* (Nat. Ord. Tiliaceæ). As a general rule the former yields the more valuable fibre. There are numerous

varieties of both species, and the Agricultural Department in Bengal have in recent years succeeded in isolating a number of races which are much above the average both in yield and quality of fibre. Samples of jute from six of these selected varieties of *C. olitorius* were received from the Fibre Expert at Dacca in January 1919, and, as will be seen from the account of their examination given in the following pages, they were all of excellent quality.

Jute (Corchorus olitorius) from India

The samples of *Corchorus olitorius* fibre which are the subject of this report were forwarded to the Imperial Institute by the Fibre Expert at Dacca, in January 1919.

No. 1. *R.* 26, *Plot A*, *Narainganj*, 1918.—A buff-coloured fibre of good lustre and strength and fairly soft, but not very well cleaned, some adherent bark being present, especially at the butt ends. Length of staple, 5 ft. to 11 ft., mostly about 8 ft.

No. 2. *R.* 26, *Plot B*, *Narainganj*, 1918.—This sample was very similar to No. 1, but was slightly longer in staple.

No. 3. *Dacca Green*, *Plot C*, *Narainganj*, 1918.—This material was slightly paler in colour than samples Nos. 1 and 2, and was strong, fairly soft and of very good lustre. The fibre had been well cleaned, but a little adherent bark was left at the butt ends. Length of staple, 5 ft. to 12 ft., mostly about 7 ft.

No. 4. *Dacca Green*, *Plot D*, *Narainganj*, 1918.—A fibre similar to sample No. 3, but a little paler and softer, and rather weak in parts.

No. 5. *R.* 30, *Plot* 7, *Chinsurah*, 1918.—This fibre was brownish-grey in colour and of good lustre, but not quite so strong as samples Nos. 1 to 4. It was well prepared, practically no bark being present. The fibre was finer, but harsher than the four preceding samples, and the length of staple was 10 ft. to 15 ft., mostly about 12 ft.

No. 6. *R.* 26, *Plot* 10, *Chinsurah*, 1918.—This sample was well prepared, pale grey to greyish-brown in colour, free from bark, and of good strength, but rather inferior in lustre to sample No. 5. The fibre was finer than samples Nos. 1 to 4 and softer than No. 5, and had a length of staple of 10 ft. to 15 ft., mostly about 12 ft.

The samples were submitted to chemical examination with the following results :

		No. 1. Per cent.	No. 2. Per cent.	No. 3. Per cent.	No. 4. Per cent.	No. 5. Per cent.	No. 6. Per cent.
Moisture		9·3	9·1	9·2	9·3	8·6	8·8
Calculated on the dry fibre	Ash	0·5	0·9	0·6	0·5	1·0	0·8
	α-Hydrolysis, loss	6·9	7·0	6·2	6·5	6·9	6·5
	β-Hydrolysis, loss	10·2	10·8	9·7	10·8	10·7	10·4
	Acid purification, loss	0·6	1·0	1·0	1·6	0·9	1·3
	Loss on washing in water	0·3	0·4	0·5	0·8	0·5	0·2
	Cellulose	77·2	77·2	77·4	77·7	77·6	77·0

These figures are similar to those recorded for well-prepared samples of high-grade ordinary jute, and do not indicate any appreciable difference between the six samples as regards their behaviour towards chemical reagents.

The samples were valued by a firm of merchants in London at the following prices, c.i.f. London (July 1919), with first native marks Calcutta jute at £60 per ton :

Sample.	Price per ton. £
1	80
2	76
3	77
4	85
5	70–75
6	65–70

In appearance and general character there is very little variation between these six samples, with the exception that Nos. 5 and 6 grown at Chinsurah are grey in colour, whilst Nos. 1 to 4 grown at Narainganj are buff-coloured. It seems that this difference may perhaps be due to the method of retting, or possibly to the character of the water used. It may be added that sample No. 3 (Dacca Green, Plot C, Narainganj) appeared to be rather superior to the other samples in lustre and strength.

Jute (*Corchorus capsularis*) *from India*

Two samples of the fibre of *C. capsularis* were received from India during 1918. One was grown in the Narainganj Agency (Bengal) and the other at Hopin, in Northern Burma.

No. 1. *Grown in Narainganj* (*Bengal*) *Agency. Variety: Kakya Bombai, No.* 7.—This variety of jute was obtained in the course of selection experiments carried out by the Fibre Expert to the Government of Bengal. It has proved to be one of the heaviest, if not the heaviest, yielders in the jute-growing tracts, and the area devoted to its cultivation is rapidly extending. About 45 tons of pure seed of this variety were produced in 1917–18, partly on an estate in Assam and partly by Bihar planters, and the seed was distributed to growers through the Bengal Department of Agriculture.

The sample of this variety of jute received at the Imperial Institute consisted of fine, lustrous, dark cream-coloured fibre. A few pieces of adherent bark were present, and the butt ends of the fibre were gummy, but on the whole the sample was clean and well prepared. The fibre was of good strength and varied in length from 9 ft. to 10 ft. 6 in.

The results of chemical examination of this fibre compared with extra fine Indian jute and "Fine Narainganj" jute are shown in the following table:

		Present sample.	Extra fine Indian jute.	"Fine Narain-ganj" jute.
		Per cent.	*Per cent.*	*Per cent.*
Moisture		9·0	9·6	8·8
Calculated on the dry fibre	Ash	0·7	0·7	0·8
	α-Hydrolysis, loss	8·9	9·1	10·3
	β-Hydrolysis, loss	11·9	13·1	13·4
	Acid purification, loss	1·0	—	3·2
	Loss on washing in water	nil	—	2·3
	Cellulose	74·0	77·7	76·6

The length of the ultimate fibres ranged from 0·8 to 4·4 mm., but was mostly from 2·0 to 3·0 mm.

The fibre was described by merchants as drier and more brittle than ordinary Bengal jute, and it was valued at £40 per ton c.i.f. in the United Kingdom, with "first marks" Calcutta jute at £45 per ton.

This sample of jute was of good quality and compared favourably in chemical composition and behaviour with previous samples of "Extra fine Indian jute" and "Fine Narainganj jute" examined at the Imperial Institute, except that the percentage of cellulose was a little lower.

The merchants regarded the sample as slightly inferior to "first marks" Calcutta jute, but the lower value of the fibre is no doubt compensated for by the large yield obtained from this variety of *Corchorus capsularis*.

No. 2. *Grown at the Hopin Agricultural Station, Northern Burma.*—Jute was grown experimentally at this Station for the first time in 1917–18. *C. capsularis* gave a yield of about 1,800 lb. per acre, but *C. olitorius* gave less than half this quantity. A sample of the former was received at the Imperial Institute. It consisted of lustrous, fairly soft, greyish fibre, containing some light brown portions. The material was only slightly interlaced, but was not very well prepared, containing some bark and being gummy in parts. It was of fairly good strength, and the length varied from 6 to 9 ft. with an average of 8 ft.

This sample gave the following results on chemical examination, compared with "Fine Narainganj" jute.

		Present sample. *Per cent.*	"Fine Narainganj" jute. *Per cent.*
Moisture		10·5	8·8
Calculated on the dry fibre	Ash	0·8	0·8
	α-Hydrolysis, loss	7·9	10·3
	β-Hydrolysis, loss	11·8	13·4
	Acid purification, loss	2·1	3·2
	Loss on washing in water	1·1	2·3
	Cellulose	76·0	76·6

Under Government control this jute would probably have realised about £52 per ton in London at the end of 1918.

The results of the chemical examination show that this sample was about equal in quality to the sample of "Fine Narainganj" jute previously examined at the Imperial Institute. It was of good length and quality, but its value would have been enhanced by better preparation.

Jute Substitutes

Fibres resembling jute, and capable of being used for similar purposes, are obtained fom a number of plants belonging to the natural orders Tiliaceae and Malvaceae. The chief of these, commercially, are *Hibiscus cannabinus* (Bimlipatam jute) and *Abutilon Avicennae* (China jute),

Less important fibres are obtained from other species of *Hibiscus* and *Abutilon*, and from species of *Sida*, *Triumfetta*, *Urena*, etc. A full account of these jute substitutes will be found in *Cotton and Other Vegetable Fibres*, by Ernest Goulding, D.Sc. (London: John Murray, 1919). Reports on samples of some of these received recently from India, Rhodesia, South Africa, Sierra Leone and Sudan are given below.

Hibiscus cannabinus Fibre from India

Two samples of *H. cannabinus* fibre grown experimentally in Burma were received early in 1918. They were as follows:

No. 1.—" Kala Chinbaung (*Hibiscus cannabinus*) from Nagu, Shwebo district, December 1917." This fibre was greyish, somewhat interlaced, and of good lustre. A few harsh and gummy portions and small pieces of adherent bark were present, but on the whole the sample was clean and well prepared. It was of good strength and varied in length from 6 to 11 ft., being mostly about 8 ft.

No. 2.—" Kala Chinbaung (*Hibiscus cannabinus*) Mandalay Farm." This fibre was also somewhat interlaced, and of good lustre. It was mostly greyish in colour, but light brown in parts. The sample was not so well prepared as No. 1, being somewhat harsher and having many gummy portions, especially at the butt ends. It was of good strength and the length ranged from 5 to 10 ft. with an average of 6 ft.

The samples were examined chemically with the results given in the following table, which includes also the corresponding figures for Bimlipatam jute for comparison.

		Sample No. 1.	Sample No. 2.	Bimlipatam jute.
		Per cent.	*Per cent.*	*Per cent.*
Moisture		9·7	10·0	12·5
Calculated on the dry fibre	Ash	1·0	1·5	1·3
	α-Hydrolysis, loss	7·5	9·9	11·8
	β-Hydrolysis, loss	10·3	13·3	15·1
	Acid purification, loss	0·8	1·7	—
	Loss on washing in water	nil	0·9	—
	Cellulose	76·3	75·6	75·4

Under the conditions obtaining in 1918 Sample No. 1 would probably have realised about £52 per ton in London and No. 2 slightly less.

Both these samples of *Hibiscus cannabinus* fibre were of satisfactory quality, comparing favourably with commercial Bimlipatam jute, but sample No. 2 was not so well prepared as No. 1. Consignments of similar fibre would be readily saleable in the United Kingdom.

Makuku Fibre from Rhodesia

Two samples of a jute-like fibre from Rhodesia were received in April 1918, under the name of "makuku." As is explained later (p. 471) the name "makuku" is applied to the fibre of more than one plant in Rhodesia, and the present samples appeared to have been prepared from *Hibiscus cannabinus*. They were as follows:

No. 1.—This consisted of fairly soft, lustrous, somewhat interlaced fibre, similar in appearance to Bimlipatam jute (*Hibiscus cannabinus*). The fibre was generally of pale straw colour, but some pale brown portions were present. The material was stiff and gummy in parts, especially at the butt ends, and some adherent bark was present, but in general the sample had been fairly well prepared. The fibre showed many signs of side branching.

The strength of the fibre was irregular, but on the whole fair. Some portions of the sample were weak, and appeared to have been over-retted. The length varied from 4 ft. to 8 ft. 6 in., being mostly about 5 ft. 6 in.

No. 2.—This sample was unevenly prepared; a fair proportion of adherent bark was present, and some portions of the fibre were gummy. The clean fibre was softer, more lustrous and rather less interlaced than the preceding sample No. 1. The material varied in colour from cream to brown and showed some signs of side branching. It had the appearance of having been prepared from smaller and possibly younger plants than sample No. 1.

The fibre was of very fair strength, and ranged in length from 3 to 5 ft., being mostly about 4 ft. long.

The fibres were examined with the results given in the

following table, compared with the corresponding figures for Bimlipatam jute :

		No. 1.	No. 2.	Bimlipatam jute.
		Per cent.	*Per cent.*	*Per cent.*
Moisture		8·4	8·7	12·5
Calculated on the dry fibre	Ash	0·6	0·4	1·3
	α-Hydrolysis, loss	10·5	9·5	11·8
	β-Hydrolysis, loss	14·0	14·6	15·1
	Acid purification, loss	1·6	0·8	—
	Loss on washing in water	1·2	nil	—
	Cellulose	77·5	77·4	75·4

Sample No. 1 was valued by a firm of fibre merchants at about 10 per cent. under the current value of Bimlipatam jute, *i.e.* about £40 per ton under war conditions (July 1918), or £12 per ton in pre-war times.

The second sample was regarded as being of similar value to "first marks" Bengal jute, or say £45 per ton in July 1918, and £18 per ton in pre-war times.

Fibre represented by these samples should be readily saleable as jute substitutes. No. 2 was superior in character to No. 1, being softer, more lustrous and less interlaced ; it was, however, shorter in staple than sample No. 1, and some portions were not well prepared.

Jute Substitutes from Northern Rhodesia

A series of six different fibres from Northern Rhodesia were received in July 1918. They were accompanied by herbarium specimens, which were submitted to Kew for identification. Two of the fibres were submitted under the native names "makuku" and "makuku musitu," respectively. The former proved to be derived from a form of *Hibiscus cannabinus* and the other from *Urena lobata*. A third fibre called "mukuku" was derived from *Sida cordifolia*.

No. 1. "*Makuku*" *fibre* (*Hibiscus cannabinus*, Linn., forma).—Pale-coloured, very lustrous fibre, well cleaned and prepared, and less harsh than usual for *H. cannabinus* fibre (Bimlipatam jute). It was of good strength, with an average length of 4 ft.

The results of examination of this fibre, compared with commercial Bimlipatam jute and "Fine Narainganj" jute, are given on the next page :

		Present sample.	Commercial Bimlipatam jute (*Hibiscus cannabinus*).	"Fine Naraingānj" jute. (*Corchorus* sp.).
		Per cent.	*Per cent.*	*Per cent.*
Moisture		10·0	12·5	8·8
Calculated on the dry fibre	Ash	0·4	1·3	0·8
	α-Hydrolysis, loss	9·2	11·8	10·3
	β-Hydrolysis, loss	13·6	15·1	13·4
	Acid purification, loss	0·6	—	3·2
	Loss on washing in water	0·4	—	2·3
	Cellulose	77·8	75·4	76·6

The fibre was valued by merchants in London at £5 above "first marks" Calcutta jute, the current price of which was £45 per ton c.i.f. United Kingdom (December 1918). The average pre-war price of "first marks" jute was about £21 per ton, but the value varies considerably according to market and crop fluctuations.

The results of the chemical examination of this sample are normal for well-prepared, high-grade Hibiscus fibre. Similar material would be readily saleable in the United Kingdom.

No. 2. "Makuku Musitu" fibre (*Urena lobata*, Linn.).—Pale-coloured, lustrous fibre which was clean and well prepared, but rather harsh and brittle and inclined to be "strappy" (*i.e.* interlaced so that it splits readily into short filaments). It was somewhat inferior to the majority of the previous samples of Urena fibre examined at the Imperial Institute. The strength was good on the whole, and the length varied from 2 ft. 6 in. to 4 ft. with an average of about 3 ft.

The fibre was examined with the following results, compared with *U. lobata* fibre from India.

		Present sample.	*Urena lobata* fibre from India.
		Per cent.	*Per cent.*
Moisture		10·8	10·6
Calculated on the dry fibre	Ash	0·8	0·3
	α-Hydrolysis, loss	8·5	9·4
	β-Hydrolysis, loss	11·8	13·4
	Acid purification, loss	1·0	1·1
	Loss on washing in water	nil	—
	Cellulose	80·5	77·5

Merchants in London valued this fibre at £5 above "first marks" Calcutta jute (see page 467).

This fibre was somewhat inferior to sample No. 1, but was valued at the same price. The results of examination show that the material is similar to *U. lobata* fibre from India in its behaviour towards chemical reagents. Such fibre would be readily saleable in the United Kingdom.

No. 3. "*Mukuku*" *fibre* (*Sida cordifolia*, Linn.).—Soft, very lustrous fibre, well cleaned and prepared, of pale colour and similar to good jute. It was of very good strength and varied in length from 3 to 5 ft., the average being 4 ft.

The results of chemical examination of this fibre, compared with fibre of *Sida* sp. from India, were as follows :

		Present sample. *Per cent.*	Fibre of *Sida* sp. from India. *Per cent.*
Moisture		8·5	10·2
Calculated on the dry fibre	Ash	0·5	0·5
	α-Hydrolysis, loss	9·5	6·5
	β-Hydrolysis, loss	13·6	9·0
	Acid purification, loss	1·4	0·5
	Loss on washing in water	0·5	—
	Cellulose	77·8	75·6

The fibre was regarded by merchants in London as suitable for use in the finest jute fabrics and was valued at £5 above "first marks" Calcutta jute (see page 467).

This fibre was of satisfactory composition, well cleaned and prepared, and would be readily saleable in the United Kingdom.

No. 4. "*Sipossiwanena*" *fibre* (*Hibiscus vitifolius*, Linn., var.).—This fibre was of pale colour, and free from gum or bark ; it was, however, of a strappy or interlaced character, rather harsh, weak and somewhat lacking in lustre. On the whole it had the appearance of having been overretted. The strength was uneven, and on the whole weak, though in parts good. It varied in length from 3 to 5 ft., with an average of about 4 ft.

The following results were obtained on chemical examination :

		Per cent.
Moisture		8·9
Calculated on the dry fibre	Ash	0·6
	α-Hydrolysis, loss	8·7
	β-Hydrolysis, loss	11·9
	Acid purification, loss	1·2
	Loss on washing in water	0·2
	Cellulose	78·2

Merchants in London considered that the value of the fibre in this condition would be below that of "first marks" Calcutta jute (see page 467), as the decortication was imperfect and the fibre was rather harsh. The material would, however, be suitable for the manufacture of coarse yarn.

The losses on hydrolysis as shown above are low, and the amount of cellulose high, but it is possible by over-retting to remove non-cellulose constituents from fibres, which then give abnormal figures on analysis. This may have occurred in the present case.

No. 5. "Likaru" or "Lukawa" fibre (Triumfetta pentandra, A. Rich.).—A well-cleaned and prepared fibre, fairly soft and fine, and of fair lustre. The strength varied from very fair to good, and the length ranged up to 3 ft., with an average of about 2 ft.

The results of chemical examination of this fibre, compared with the fibre of *T. rhomboidea* from Nyasaland, were as follows:

		Present sample.	*Triumfetta rhomboidea* fibre from Nyasaland.
		Per cent.	*Per cent.*
Moisture		8·7	10·4
Calculated on the dry fibre	Ash	0·4	0·6
	α-Hydrolysis, loss	10·9	9·1
	β-Hydrolysis, loss	14·0	14·7
	Acid purification, loss	1·0	3·4
	Loss on washing in water	0·2	—
	Cellulose	78·2	76·2

This fibre was described by merchants as soft and spinnable and worth about the same price as "first marks" Calcutta jute (see page 467).

This fibre was similar in composition and appearance to the fibres of other species of *Triumfetta* and to jute, and would be readily saleable in the United Kingdom.

No 6. "Mukangandope" fibre (Abutilon angulatum, Mast.).—This fibre was pale and lustrous, but was "strappy" and weak and brittle in parts. It was well cleaned on the whole, but some of it was harsh owing to the presence of gum and bark. It was of rather poor strength, and varied in length from 3 ft. 4 in. to 5 ft.

The results of chemical examination of the fibre were as follows:

		Per cent.
Moisture		9·6
Calculated on the dry fibre	Ash	1·4
	α-Hydrolysis, loss	7·2
	β-Hydrolysis, loss	10·0
	Acid purification, loss	2·0
	Loss on washing in water	0·7
	Cellulose	75·2

Merchants in London stated that this fibre was similar to China jute in colour and texture, but was much shorter and brittle. They valued it at about £95 per ton under war conditions (December 1918).

This fibre was satisfactory in its behaviour towards chemical reagents, but it was inferior to most of the fibres used as jute substitutes.

It may be pointed out that China jute under normal conditions is worth less than Calcutta jute, *e.g.* £16 to £18 per ton with "first marks" jute at about £33 (June 1914). The high price quoted above in comparison with Calcutta jute appears to be due to the fact that no control price was fixed for China jute.

General Remarks on the Fibres.—The six fibres should be readily saleable as jute substitutes for use in the manufacture of yarns, fabrics and twine. They were, however, much shorter than commercial jute or the usual jute substitutes, which are frequently 8 ft. or more in length. Samples Nos. 1 to 5 were well cleaned and prepared, but No. 4 appeared to have been over-retted. Sample No. 6 (*Abutilon angulatum*) would be saleable in the United Kingdom as "China jute," a material which under normal conditions realises lower prices in the market than either true jute or Bimlipatam jute and other jute substitutes.

Sida rhombifolia Fibre from South Africa

A sample of *S. rhombifolia* fibre was received from South Africa in July 1918. It was prepared at the Botanical Laboratories, Pretoria, from wild plants growing in waste places round Pretoria, where it is said to be a common weed.

The sample consisted of a soft, pale cream fibre, fairly lustrous on the whole, but rather dull and weak in parts, and having a general appearance of having been over-

retted, though it was still rather gummy at one end. The fibre ribbons were very narrow and short, suggesting that they were derived from young or poorly developed plants. The material was of uneven strength and on the whole weak. The length varied from 14 to 37 in., being mostly 24 to 30 in.

The results of chemical examination of this fibre, compared with Sida fibre from Nyasaland and India, are given in the following table :

		Present sample.	Sida fibre from Nyasaland.	Sida fibre from India.
		Per cent.	*Per cent.*	*Per cent.*
Moisture		10·7	10·3	9·5
Calculated on the dry fibre	Ash	1·1	1·0	0·4
	α-Hydrolysis, loss	10·2	8·5	7·3
	β-Hydrolysis, loss	14·1	13·5	10·4
	Acid purification, loss	1·2	1·8	0·8
	Loss on washing in water	1·0	—	—
	Cellulose	76·5	77·4	75·5

This fibre would no doubt find a market in the United Kingdom, but would realise much better prices if it were of greater length. Well-prepared *Sida rhombifolia* fibre from India, which is usually from 5 to 6 ft. long, has been sold in London at prices equal to that of "first marks" jute, the value of which was £36 per ton f.o.b. Calcutta in March 1919.

The present sample of fibre behaved normally towards chemical reagents, and was soft and silky, but much shorter than is usual for well-grown *S. rhombifolia* fibre.

It seems possible that the wild plants do not grow to any great size in the locality from which this sample was derived, and in this case the length of staple could perhaps be improved if the plants were cultivated. In Natal, however, the plant is said to grow wild to a height of 3 to 5 ft.

Hibiscus fibre from the Sudan

A sample of Hibiscus fibre prepared at Kegulu, Sudan, was received in January 1918. It consisted of harsh, coarse, lustrous, somewhat interlaced fibre of very pale silver-grey colour. It was fairly well cleaned and prepared, but rather harsh and gummy at the butt ends, and

showed signs of some side branching. The strength was good on the whole, but rather uneven. The length varied from 5 to 8 ft., being mostly about 6 ft.

The fibre was examined chemically with the following results, compared with Bimlipatam jute.

		Present sample.	Bimlipatam jute (*Hibiscus cannabinus*) from India.
		Per cent.	*Per cent.*
Moisture		9·1	12·5
Calculated on the dry fibre	Ash	0·4	1·3
	α-Hydrolysis, loss	8·3	11·8
	β-Hydrolysis, loss	13·5	15·1
	Acid purification, loss	1·8	—
	Loss on washing in water	0·8	—
	Cellulose	78·5	75·4

A firm of merchants reported that the fibre was rather coarser and harsher than Bimlipatam jute from India. They regarded the strength and colour as satisfactory, but remarked that the retting was imperfect as shown by the coarse root ends. It was pointed out that fibre represented by the sample would realise very high prices in London at the time (July 1918) so long as it did not come under Government control, and the merchants stated that a similar coarse fibre had been sold in the United Kingdom at £98 per ton, although the price fixed by the War Office for Bengal jute was then £45 per ton for spot supplies.

This fibre was similar in chemical character to Bimlipatam jute, but it was coarser, harsher and more interlaced. It would be inferior to Bimlipatam jute for spinning purposes.

Cordage Fibres

Sisal Hemp and Henequen from Jamaica

Reference has already been made in this Bulletin (1915, **13**, 160) to the introduction of Sisal hemp (*Agave Sisalana*) and henequen (*A. fourcroydes*) into Jamaica, and it is pointed out that the former has grown well on limestone soil in Vere, whilst henequen has done well on alluvial soil in St. Elizabeth. More recent experiments at Lititz (Southern St. Elizabeth) and at Hope (near Kingston) have

confirmed these results as regards the type of soil most suitable for the two plants.

It was found that on the alluvial non-calcareous soil at Hope Sisal poles in about two years, whereas henequen grows for over fourteen years on such soil before poling. At Lititz, where an area of very barren limestone soil was planted in 1914 with the two fibres (5 acres each), Sisal produced leaves 40 in. long, with an average weight of 1·06 lb., and containing 3·8 per cent. of fibre, whilst the henequen leaves were only 34 in. long, weighed 0·94 lb. and contained 3·6 per cent. of fibre (*Rept. Dept. Agric., Jamaica*, 1918–19, pp. 5, 14). The yield of Sisal at Lititz, with plants set out at 6 ft. by 5 ft., is estimated at about ¾ ton per acre for the first crop. The cost of bringing an acre of Sisal to the harvesting stage at Lititz was about £3, and as the fibre is of excellent quality the financial success of the industry appears most promising. Altogether 500 acres were planted with Sisal at Lititz by March 1919, and sufficient plants for a further 400 acres have been provided. It is interesting to note that this land at Lititz has hitherto been regarded as so useless that, although bounded by a main road, no one has ever been willing to pay taxes on the land or to own it. It is hoped to erect a factory for preparing the fibre in 1920, when the first crop at Lititz will be ready to reap.

Sisal is already being taken up by private planters, and a yield of one ton of fibre per acre has been obtained for the first crop on a new plantation in Clarendon.

It is suggested in the *Report* above referred to, that from a preliminary consideration of the matter the following areas are the most suitable for Sisal in Jamaica: the coastal lands east of Manchioneal, in Portland; coast lands from Yallahs to the "Eleven Mile" on the Windward Road, in St. Thomas; the limestone area north of the Vere plain in Clarendon; the savannah lands of south-east St. Elizabeth and the coastal limestone lands west of Black River in St. Elizabeth; any accessible areas of red soil or limestone lands throughout the parishes of Manchester and St. Ann; dry limestone lands south and south-east of Falmouth, in Trelawny; and second-class limestone lands in Hanover and St. James. It is pointed

out that as a minimum 200 acres should be planted up in the first year, and then 100 acres yearly until 700 acres have been planted, when the original 200 acres will need replanting, preferably with suckers grown in a nursery from bulbils.

With a view to directing the attention of landowners to the value of the fibres as plantation crops for Jamaica, it is intended to plant henequen along the first twenty-four miles of the Government railway from Kingston to Montego Bay where the soil is alluvium, and to plant Sisal along the remaining 120 miles of the railway, which passes over limestone.

Samples of Sisal hemp and of henequen produced at both Lititz and Hope were examined at the Imperial Institute early in 1919 and are dealt with below.

No. 1. " Sisal fibre (*Agave Sisalana*) from plants four years old grown at Lititz on limestone soil." Cream coloured, lustrous fibre, of good bold quality. A small quantity of brownish fibre was present, and the sample also contained a little pith and leaf epidermis, mostly at the butt ends of the fibres. The strength was uneven, and on the whole rather poor. The length varied from 2 ft. to 4 ft. 3 in., being mostly about 3 ft. 6 in.

The results of chemical examination were as follows :

		Per cent.
Moisture		7·5
Calculated on the dry fibre	Ash	0·5
	α-Hydrolysis, loss	13·5
	β-Hydrolysis, loss	15·2
	Acid purification, loss	4·1
	Loss on washing in water	2·7
	Cellulose	77·3

This fibre was valued in London at about £55 per ton with prime African Sisal at £60 per ton (May 1919). It would be readily saleable in large quantities in the United Kingdom.

No. 2. " Henequen fibre (*Agave fourcroydes*) from plants four years old grown at Lititz on limestone soil." Pale buff-coloured fibre, of fair lustre, but not very well cleaned and prepared, a small amount of pith being present. This fibre was inferior to the other three samples. It was

rather weak, and varied in length from 2 ft. to 2 ft. 10 in., being mostly about 2 ft. 6 in. long.

The fibre was examined with the following results :

		Per cent.
Moisture		9·1
Calculated on the dry fibre	Ash	1·1
	α-Hydrolysis, loss	16·4
	β-Hydrolysis, loss	17·8
	Acid purification, loss	2·4
	Loss on washing in water	1·4
	Cellulose	74·2

The fibre was valued in London at about £40 per ton (May 1919), but would be worth more if of greater length.

No. 3. "Sisal fibre (*Agave Sisalana*) from plants four years old grown at Hope Gardens on gravelly non-calcareous soil." Clean, cream coloured, lustrous fibre, well prepared and of good bold quality. There were some dark-brown adherent particles at the ends of the fibres. The material was of good strength and ranged in length up to 5 ft. or 5 ft. 6 in., being mostly about 4 ft.

The results of chemical examination of this fibre were as follows :

		Per cent.
Moisture		7·8
Calculated on the dry fibre	Ash	0·5
	α-Hydrolysis, loss	10·6
	β-Hydrolysis, loss	13·3
	Acid purification, loss	1·3
	Loss on washing in water	1·0
	Cellulose	77·9

The fibre was valued in London at about £60 per ton (May 1919), *i.e.* at the current price of prime East African fibre. Such fibre would be readily saleable in large quantities in the United Kingdom.

No. 4. "Sample of henequen fibre (*Agave fourcroydes*) from plants about ten years old grown at Hope Gardens on gravelly non-calcareous soil." Good bold fibre, of pale cream colour and good lustre, and well cleaned and prepared. The material was of bolder quality and better strength than the henequen fibre grown at Lititz (Sample No. 2). The length ranged up to 5 ft. or 5 ft. 6 in., being mostly about 4 ft. 3 in.

The following results were obtained on chemical examination :

		Per cent.
Moisture		8·2
Calculated on the dry fibre	Ash	0·9
	α-Hydrolysis, loss	14·9
	β-Hydrolysis, loss	17·6
	Acid purification, loss	3·1
	Loss on washing in water	1·9
	Cellulose	75·0

This fibre was valued in London at about £57 per ton (May 1919).

General Remarks.—These four samples of Sisal hemp and Henequen fibre were of normal composition. The Henequen fibres contained less cellulose than the Sisal hemp, and were less resistant to the action of alkali, as is indicated by the results of the *a*- and *β*-hydrolyses.

The fibres are all of good appearance and quality with the exception of sample No. 2, representing Henequen fibre from four year-old plants grown at Lititz, which is very short and rather inferior in strength and lustre.

Fibre of the quality of samples Nos. 1, 3 and 4 would be readily saleable in London in large quantities.

Henequen Fibre from British Honduras

The sample of Henequen fibre which is the subject of this report was forwarded to the Imperial Institute in July 1917.

The material was submitted in response to a suggestion made by the Imperial Institute in 1916 that samples of any fibres which are abundant in the Colony should be forwarded for examination and valuation.

The sample consisted of small " hanks " of fibre each of which was tied at the butt end, and apparently consisted of the fibre from a single leaf. The fibre was very clean, well-prepared, lustrous and of pale colour, and similar in appearance to commercial Sisal hemp of good quality. It was 3 to 4 ft. in length (mostly from 3 to 3½ ft.) and exhibited very good strength.

The fibre was submitted to chemical examination at the Imperial Institute and the results are shown in the

following table, together with those recorded for previous samples of Sisal hemp from British Honduras and the East Africa Protectorate:

		Present sample.	Previous sample of Sisal hemp from British Honduras.	Sisal hemp from British East Africa.
		Per cent.	*Per cent.*	*Per cent.*
Moisture		7·5	10·1	9·6
Calculated on the dry fibre	Ash	1·3	0·7	0·8
	α-Hydrolysis, loss	12·2	11·3	11·3
	β-Hydrolysis, loss	14·3	13·6	14·8
	Acid purification, loss	3·2	2·3	2·1
	Loss on washing in water	3·7	2·6	—
	Cellulose	77·2	75·7	77·4
Length of ultimate fibres		From 1·7 to 5·9 mm.; mostly 2·0 to 3·0 mm.	—	—

It will be seen from these figures that the present sample closely resembles in chemical composition and behaviour previous samples of Sisal hemp received at the Imperial Institute from British Honduras and the East Africa Protectorate.

The fibre was regarded by a firm of brokers in London as of ideal quality, superior to Mexican Henequen or British East African Sisal, and comparing favourably with the Sisal hemp produced in Java and Portuguese East Africa. They valued the fibre at £99 per ton in London, which was the maximum price under the conditions then obtaining (July 1918).

The firm suggested that the fibre should not be tied in small hanks like the present sample, but packed in "heads" of several pounds each, so as to avoid the unnecessary expense of untying the hanks in the process of "opening" the fibre for manufacturing purposes.

Henequen fibre similar to this sample would be readily saleable in the United Kingdom at good prices.

Sisal Hemp from Sierra Leone

A sample of Sisal hemp was received from Sierra Leone in October 1919. It consisted of lustrous fibre, fairly well cleaned and prepared, but of uneven colour, varying from pale cream to very pale brown. The brownish portions

were chiefly at the ends of the strands. It was of fairly good but rather uneven strength, and its length varied from 6½ to 7 ft.

The results of chemical examination, compared with East African Sisal hemp were as follows :

		Present sample. Per cent.	East African Sisal hemp. Per cent.
Moisture		8·9	9·6
Calculated on the dry fibre	Ash	0·6	0·8
	α-Hydrolysis, loss	10·3	11·3
	β-Hydrolysis, loss	12·7	14·8
	Acid purification, loss	1·5	2·1
	Loss on washing in water	0·5	—
	Cellulose	77·6	77·4

The sample was regarded by fibre merchants as well grown, of exceptional length, and equal in quality to No. 2 African Sisal. The value of consignments of similar character would be about £50 per ton in London (December 1919), and the fibre would be saleable in large quantities.

The results of the examination recorded above show that this fibre compared favourably in chemical character and composition with Sisal hemp of good quality from East Africa. The commercial value of the material could be enhanced by the exercise of greater care in its preparation, and in this connection it may be pointed out that the appearance of the fibre would be considerably improved by brushing.

Mauritius Hemp from Rhodesia

A sample of Mauritius hemp (*Furcraea gigantea*) was received from Rhodesia in April 1918. It was composed of fibres of mixed character, varying from moderately coarse to fine. On the whole it was insufficiently prepared, containing a good deal of pithy matter ; the variations in lustre and colour appeared to indicate insufficient washing. It was of fair strength and varied in length from 4 ft. to 7 ft., being mostly about 6 ft.

The fibre was submitted to chemical examination with the results given in the following table, which also includes the corresponding figures for previous samples examined at the Imperial Institute.

		Present sample.	Previous samples from Rhodesia. No. 1.	No. 2.
		Per cent.	Per cent.	Per cent.
Moisture		8·1	10·1	9·7
Calculated on the dry fibre	Ash	0·7	1·6	0·7
	α-Hydrolysis, loss	13·1	14·8	10·4
	β-Hydrolysis, loss	15·5	17·8	13·9
	Acid purification, loss	2·8	4·4	0·9
	Loss on washing in water	1·6	—	—
	Cellulose	76·9	72·0	77·0

A firm of merchants valued the sample at £100 per ton c.i.f. United Kingdom in July 1918, owing to high freight charges, but they stated that Mauritius hemp can be bought in producing markets at about £25 per ton. The pre-war price of Mauritius hemp in the United Kingdom was only £23 to £27 per ton.

This fibre was of fair quality, but it could be improved by more thorough scraping and washing.

Sansevieria Fibres from Northern Rhodesia

Two samples of fibre prepared in Northern Rhodesia from different species of Sansevieria were received in July 1918.

No. 1. "Musokelazebe" or "Sakachebi" Fibre (Sansevieria cylindrica).—Pale straw-coloured fine hard fibre, of fair lustre, rather unevenly cleaned and prepared, and containing a fair amount of adherent pith in parts. It was similar in character to previous samples of *S. cylindrica* and *S. guineensis* fibre examined at the Imperial Institute. It was rather weaker than usual for Sansevieria fibre of this type, and varied in length from 2 ft. to 3 ft.

The results of chemical examination of the fibre, compared with *S. cylindrica* fibre from the Belgian Congo and *S. guineensis* fibre from Sierra Leone, were as follows :

		Present sample.	*S. cylindrica* fibre from Belgian Congo.	*S. guineensis* fibre from Sierra Leone.
		Per cent.	Per cent.	Per cent.
Moisture		7·7	8·5	10·6
Calculated on the dry fibre	Ash	0·3	0·4	0·4
	α-Hydrolysis, loss	8·2	9·0	8·9
	β-Hydrolysis, loss	11·4	13·0	13·9
	Acid purification, loss	1·1	1·1	1·8
	Loss on washing in water	1·0	1·1	—
	Cellulose	76·0	74·0	78·0

Merchants in London described this fibre as somewhat brittle, similar in appearance to dressed Bombay Aloe fibre, and rather short, but suitable for ropemakers' purposes and worth £50 per ton (December 1918).

The results of the chemical examination of this sample are normal for Sansevieria fibre of this character. The material has, however, been insufficiently scraped and washed and could be improved in quality by more careful preparation. The fibre would be readily saleable in the United Kingdom.

No. 2. "Lukushe" or "Lukosu" Fibre.—A pale buff-coloured, hard, fine fibre, of fair lustre, well cleaned and prepared. It was of very good strength, but only 10 to 20 in. long.

The plant yielding the fibre was regarded by Kew as being probably *Sansevieria fasciata*, Cornu. The material appeared to have been derived from the same plant as the "Lokosi" fibre previously examined at the Imperial Institute (see this BULLETIN, 1905, **3**, 318). It resembled the latter in character, but the earlier sample was of better length.

The results of chemical examination are given in the following table, which includes also those obtained in the case of the previous sample of "Lokosi" fibre:

		Present sample.	"Lokosi" fibre from N.W. Rhodesia.
		Per cent.	*Per cent.*
Moisture		8·9	9·2
Calculated on the dry fibre	Ash	0·8	1·3
	α-Hydrolysis, loss	10·2	15·4
	β-Hydrolysis, loss	13·3	21·4
	Acid purification, loss	1·7	6·0
	Loss on washing in water	2·0	—
	Cellulose	79·6	70·3

This fibre was too short to be of commercial value for rope making.

THE UTILISATION OF NEW ZEALAND HEMP WASTE

It has already been pointed out in this BULLETIN (1918, **16**, 134) that very large quantities of waste are obtained in the course of extracting the fibre from the leaves of *Phor-*

mium tenax (New Zealand hemp), and an account was given of an investigation carried out at the Imperial Institute with material sent from St. Helena on the possible utilisation of the waste as a paper-making material, and as a manure and source of potash. At the instance of the Imperial Institute Committee for New Zealand, a sample of the waste was recently forwarded from New Zealand for further investigation.

The waste, as received from New Zealand, was in the form of a coarse brown powder, mixed with masses of tangled and partially separated fibre which amounted to 3½ per cent. by weight of the whole.

Fibre.—The fibre as separated by sifting was short, tangled, weak and of dark colour, and in parts imperfectly freed from the leaf tissue. It is unlikely that such fibre would find a market except for paper-making, and for that purpose it would have to compete with sacking waste, rope waste and similar materials.

Powder.—After removal of the tangled fibre, the powder was examined (1) as a possible feeding-stuff, and (2) as a manure, with the following results :

(1) *As a Feeding-stuff.*

The composition of the material was as follows :

	Per cent.
Moisture	8·6
Crude proteins	7·9
Fat	3·8
Starch	nil
Carbohydrates, etc., by difference	41·6
Fibre	27·0
Ash	11·1
Substances soluble in cold water	22·2 (including 4·4 of ash constituents).
Nutrient ratio [1]	1 : 6·4
Food units [2]	71

[1] *The ratio between the percentage of crude proteins and the sum of the percentages of starch and fat, the latter being first converted into its starch equivalent.*

[2] *The total obtained by adding the percentage of starch to 2·5 times the sum of the percentages of fat and crude proteins.*

These results show that the Phormium waste (after being freed from the longer fibres) contains only low per-

centages of proteins and fat, is devoid of starch, and contains a rather large amount of fibre. It has a distinctly unpleasant taste, and even if animals could be induced to eat it and its consumption produced no ill-effects, the material would only be of low value as a feeding-stuff.

(2) *As a Manure.*

In the following table the results of the examination of the present sample are compared with those obtained with the samples of Phormium waste from St. Helena previously examined at the Imperial Institute (*loc. cit.*, p. 136) and with those recorded for long-straw stable manure :

	Present sample from New Zealand.	Samples of Phormium waste from St. Helena.		Fresh long-straw stable manure.
		Rotted.	Sun-dried.	
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	8·6	8·9	8·3	66·17
Nitrogen	1·26	1·07	1·00	0·54
Ash	11·1	18·5	11·1	—
Potash (K_2O)	1·93	3·93	2·93	0·67
Phosphoric acid (P_2O_5)	0·50	0·40	0·34	0·32

When expressed on the moisture-free materials, the percentages of nitrogen, potash and phosphoric acid are as follows :

	Present sample from New Zealand.	Samples of Phormium waste from St. Helena.		Fresh long-straw stable manure.
		Rotted.	Sun-dried.	
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Nitrogen N	1·38	1·17	1·09	1·61
Potash K_2O	2·11	4·31	3·19	1·99
Phosphoric acid P_2O_5	0·55	0·44	0·37	0·94

Analysis of the ash gave the following results :

	Ash of present sample from New Zealand.	Ash of samples of Phormium waste from St. Helena.	
		Rotted.	Sun-dried.
	Per cent.	*Per cent.*	*Per cent.*
Potash K_2O	17·36	21·24	26·40
Soda Na_2O	10·45	6·24	7·98
Chlorine Cl	4·81	—	6·81
Sulphuric acid SO_3	1·71	—	1·36
Phosphoric acid P_2O_5	4·50	2·16	2·93

The results of the chemical examination of the Phormium waste from New Zealand show that it would have considerable manurial value on account of the nitrogen, potash and phosphoric acid which it contains. The

amounts of nitrogen and phosphoric acid did not differ much from those contained in the samples of rotted and sun-dried waste from St. Helena, but the percentage of potash present was less than that in the latter samples. Comparing the air-dried Phormium waste with fresh long-straw stable manure it will be seen that for equal weights the former contains more than twice as much nitrogen as the latter, rather more phosphoric acid, and a considerably larger amount of potash. If, however, the waste were used in a wet condition the percentage of the manurial constituents would of course be correspondingly reduced.

An alternative method of utilising the waste for manurial purposes would be to burn it, and to apply the ash to the soil. On the basis of the above results one ton of the air-dried waste represented by the sample from New Zealand would yield on burning 248 lb. of total ash containing 43 lb. of potash (K_2O). The ash would therefore form a valuable potash manure, but as it also contains a large percentage of soda in the form of sodium carbonate care would have to be exercised in applying it to plants particularly sensitive to the action of the latter salt.

With reference to the burning of the waste for the production of the ash, it was found in small-scale trials at the Imperial Institute that the sun-dried waste from St. Helena burnt slowly and held fire well, so that the material could probably be burnt successfully in heaps (*loc. cit.*, p. 138).

The results of the present investigation confirm those obtained with the Phormium waste from St. Helena, and indicate that the best use of the waste would be as a manure, for which purpose either the original material or the ash obtained on burning it could be employed. The ash might also serve as a source of potash salts.

PAPPEA SEEDS OF SOUTH AFRICA AS A SOURCE OF OIL

The seeds of *Pappea capensis*, Eckl. et Zeyh. (Sapindaceae) have been examined recently at the Imperial Institute at the request of the Division of Botany, South Africa, in order to ascertain their value as a source of oil.

P. capensis is a shrub or small tree, yielding a leathery, hard fruit about ½ in. in diameter. According to Sim (*Forest Flora of Cape Colony*) the plant occurs abundantly on shale in the carroid scrub of the Fish river and other valleys within forty miles of the sea from Uitenhage to King William's Town, and more sparingly eastwards. It is also found in Namaqualand. The wood is white, hard and close-grained ; Pappe in his *Silva capensis* states that it is used for furniture, yokes, poles, ploughs, etc.

The seeds examined at the Imperial Institute were stated to have been collected near Alicedale in the Cape Province. They were reddish-brown in colour and almost spherical, measuring from 0·2 to 0·3 in. in diameter. A fair number of the seeds had been attacked by insects. The shells were brittle, and could easily be separated from the soft kernels, which were yellow and very oily.

The seed consisted of shell 35 per cent. and kernel 65 per cent. The average weight of a single seed was 0·26 gram and of a kernel 0·17 gram.

The entire seeds as received were found to contain 7·4 per cent. of moisture and to yield 47·8 per cent. of oil, equivalent to a yield of 73·5 per cent. from the kernels.

The oil was of golden-yellow colour and fairly viscous. It deposited a small amount of stearin on standing. On chemical examination it gave the following results, which are shown in comparison with the figures recorded for ground-nut and olive oils :

	Pappea capensis oil.	Ground-nut oil.	Olive oil.
Specific gravity at 15°/15°C.	0·9150	0·916 to 0·918	0·915 to 0·918
Solidifying point of fatty acids	39·5°C.	28·1 to 29·2°C.	16·9 to 26·4°C.
Acid value	13·1	—	—
Saponification value	188·0	190 to 196	190 to 195
Iodine value *per cent.*	69·8	87 to 98	80 to 87
Unsaponifiable matter *per cent.*	0·54	0·4 to 0·8	0·5 to 2·0
Volatile acids, soluble	0·42	—	—
„ „ insoluble	0·32	—	—
Acetyl value	21·1	9·06	10·64
Optical rotation	nil	—	—

The above figures indicate that the Pappea oil is of the "non-drying" type, and could probably be used either for soap manufacture or as a lubricant.

The residual meal left after extracting the oil from the entire seeds was light brown and had a mild, very faintly bitter flavour. The meal obtained from the decorticated kernels had a similar flavour, but was of cream colour. Both these meals were analysed at the Imperial Institute, and the results are given below in comparison with the figures recorded for undecorticated and decorticated cotton-seed meal :

	Pappea capensis meal.				Figures recorded for cotton-seed meal.	
	Meal from undecorticated seeds.		Meal from decorticated kernels.			
	As prepared at the Imperial Institute.	Calculated to correspond to 6·5 per cent. of fat for comparison with undecorticated cotton-seed meal.	As prepared at the Imperial Institute.	Calculated to correspond to 10 per cent. of fat for comparison with decorticated cotton-seed meal.	Undecorticated.	Decorticated.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture . . .	9·2	8·7	7·4[1]	6·7	13·75	7·4
Crude proteins consisting of :	16·3	15·4	38·3	34·5	24·62	42·37
True proteins .	13·5	12·8	28·7	25·9	—	—
Other nitrogenous substances .	2·8	2·6	9·6	8·6	—	—
Fat	1·0	6·5	0·4	10·0	6·56	10·16
Carbohydrates (by difference) .	51·9	49·1	42·9	38·9	29·28	25·86
Fibre . . .	18·6	17·5	5·1	4·6	21·19	7·06
Ash . . .	3·0	2·8	5·9	5·3	4·60	7·15
Nutrient ratio[1] .	1 : 3·3	1 : 4·2	1 : 1·1	1 : 1·8	1 : 1·67	1 : 1·16
Food units[2] .	95	103	140	150	107	157

[1] *The ratio between the percentage of crude proteins and the sum af the percentages of starch and fat, the latter being first converted into its starch equivalent.*

[2] *The total obtained by adding the percentage of starch to 2·5 times the sum of the percentages of fat and crude proteins.*

The above figures indicate that the meals from the whole and decorticated seed of *Pappea capensis* have a fairly good nutritive value though they are inferior to the corresponding products obtained from cotton seed.

The Pappea meal contained no alkaloid or cyanogenetic glucoside, but a saponin was present which gave the meal a slightly bitter flavour. Emulsification and frothing tests were made with the meal in comparison with tea-seed cake and *Bassia longifolia* meal, and the results indicated that the Pappea meal contained a much smaller amount

of saponin than these materials. The meal could, however, not be recommended as a feeding-stuff until practical trials have been carried out to ascertain whether it is harmless.

If the meal should prove unsuitable for use as a feeding-stuff, it might be employed as a manure, but as the meal from the undecorticated seed contains only about 2·6 per cent. of nitrogen and 0·7 per cent. of phosphates (calculated as P_2O_5) it would realise only a low price in normal conditions. Rape seed cake, which contains about 5 per cent. of nitrogen and 2·5 per cent. of phosphates, was sold in pre-war times at about £2 per ton in the United Kingdom.

A firm of oil-seed crushers stated that the oil was not suitable for edible purposes, and could not be rendered suitable by any of the ordinary refining processes. The oil would therefore have to be regarded mainly as a soap-making material, for which purpose its value under normal conditions would be about equal to that of cotton-seed oil, which in ordinary circumstances is worth about £25 per ton in the United Kingdom, although it is at present quoted at £110 per ton.

The market value of the seed will depend to some extent on that of the residual meal, but the oil crushers stated that assuming the residual meal to be of no value they were of opinion that these *Pappea capensis* seeds would be saleable in the United Kingdom at a price rather higher than that of cotton seed if they could be offered in commercial quantities. In the present abnormal conditions the seeds might realise as much as £30 per ton in the United Kingdom. Cotton seed is at present quoted in the United Kingdom at £28 10*s*. to £29 10*s*. per ton, but before the war the usual price was only £7 to £9 per ton.

These *Pappea capensis* seeds give a good yield of oil, which could be used for soap-making or as a lubricant, and they would be of interest to oil-seed crushers in the United Kingdom if large supplies are available. The residual meals from both the whole and decorticated seeds are not such rich feeding-stuffs as the corresponding products from cotton seed, and they had a slightly bitter flavour due to the presence of saponin. Feeding trials will therefore be required in order to determine whether the meals could safely be used as a cattle food.

CASTOR SEED FROM CYPRUS

The samples of castor seed from Cyprus which are the subject of this report were forwarded to the Imperial Institute in February 1919. Four different kinds of seeds were represented, and in three of them both husked and unhusked seeds were supplied. The seed had been obtained partly from departmental trial plantations and partly from outside sources. Reference to the cultivation of castor seed in Cyprus is made in the article by Mr. Bevan in this BULLETIN (p. 513).

The results of the examination of the samples are shown in the following table:

Sample.	Sample consisted of		The clean seed contained		Acid value of oil.
	Seed.	Husk.	Moisture.	Oil.	
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Small grey seed:					
1A In husk . . .	53	47	5·4	47·0	0·94
1B Clean seed . .	—	—	5·0	47·3	1·34
Medium-sized greyish-brown seed:					
2A In husk . . .	61	39	5·6	48·3	0·87
2B Clean seed . .	—	—	5·4	48·6	0·62
Large reddish-brown seed:					
3A In husk . . .	64	36	5·1	49·2	0·74
3B Clean seed . .	—	—	5·5	50·1	0·51
Very large white and red-brown seed:					
4A Clean seed . .	—	—	5·3	50·4	1·04

The above results show that all the samples were in good condition and contained normal amounts of oil. The large reddish-brown seeds (No. 3) and the very large seeds (No. 4) contained a slightly higher percentage of oil than the smaller seeds (Nos. 1 and 2).

The Cyprus authorities desired an opinion as to which variety would be most suitable for cultivation in Cyprus for export, but it must be pointed out that this will depend chiefly on such factors as the relative suitability of the varieties to the local conditions, the yield of seed per acre, and the ease with which the seeds can be collected and husked. In this connection it may be mentioned that although the larger seeds are rather richer in oil than the smaller variety, they are more bulky than the latter, and a

given weight of them would therefore occupy more cargo space.

All these varieties of castor seed would be readily saleable in the United Kingdom if offered in commercial quantities, preferably 100 tons or more at a time. The present prices of castor seed are abnormally high and fluctuate between £30 and £40 per ton, whereas the price before the war was only from about £9 to £12 per ton. The possibility of a considerable decline in prices will have to be taken into account in connection with any scheme for the cultivation of the seed in Cyprus on a commercial scale.

DISTILLATION TRIALS WITH TALH WOOD FROM THE SUDAN

Talh (*Acacia Seyal*, Del.) is a small tree occurring in the drier parts of tropical Africa and in Arabia. It is one of the sources of Sudan gum, and the bark contains a fair amount of tannin (see this BULLETIN, 1908, **6**, 36; 1913, **11**, 412). The wood is used only as fuel in the Sudan, but it has been suggested that it might be suitable for distillation. The results of distillation trials made at the Imperial Institute with talh wood from the Sudan are shown in the following table:

Percentages by weight expressed on the wood.	Present sample.	Oak.[1]	Hard woods.[2]
Moisture	7·4	—	—
Charcoal	30·0	25·0	25 to 27
Crude pyroligneous acid containing:	44·0	53·9	45 to 50
Acetic acid	3·8	4·4	3 to 4
Dissolved tar	5·0	5·8	3·5
Methyl alcohol (100 per cent.)	1·23	1·06	1·5 to 2 (crude spirit, about 80 per cent. by volume)
Acetone	0·25	0·25	
Tar, separated containing:	7·4	6·4	—
Acetic acid	0·4	0·35	—
Total yield of tar	12·4	12·2	—
" " " acetic acid	4·2	4·75	—

[1] *Results obtained at the Imperial Institute.*

[2] *Based on figures recorded in Thorpe's "Dictionary of Applied Chemistry," vol. v. p.* 774.

The crude pyroligneous acid contained the following proportions of the constituents referred to in the above table :

	Per cent.
Acetic acid	8·7
Dissolved tar	11·4
Methyl alcohol (100 per cent.) .	2·79
Acetone	0·57

The crude separated tar contained 5·4 per cent. of acetic acid.

The Talh wood charcoal obtained in the experiments was moderately hard and brittle. It had a dull ring and showed a soft non-vitreous fracture. It held fire well and burned steadily in a draught.

The tar obtained was a brownish-black easily mobile liquid of about the same consistency as pine-wood tar. On standing it gave only a slight deposit, and on the whole had a good appearance.

The results of this investigation show that the yields of acetic acid, methyl alcohol, acetone, tar and charcoal from Tahl wood are satisfactory and are equal to those usually obtained from other hard woods.

SPECIAL ARTICLES

NOTES ON AGRICULTURE IN CYPRUS AND ITS PRODUCTS

By W. Bevan

Director of Agriculture, Cyprus

PART II[1]

Fodders and Feeding Stuffs

Carob Tree

The carob (*Ceratonia siliqua*) is indigenous in Syria, and probably also in the northern countries of Africa, whence it presumably spread to certain parts of Asia Minor, to Greece, the Greek Islands and Southern Italy.

At the time of Christ, and for some centuries later,

[1] *The first part of this article, accompanied by a sketch map of Cyprus showing the distribution of crops and forests, appeared in the last number of this* Bulletin, *Vol. XVII, No.* 3.

this tree was known to the Greeks by the name of keronia or keratea, being the Greek for horns, and is given to the locust or carob bean from its supposed resemblance to goats' horns. It is also known in different parts of Cyprus under the following names; teratsia (a corruption of keratea), xylokeratea, kountouroudia, koutsoupia and charoupia. The last named is of Arabic origin (kharroub) and the same root of the word is common all over Europe. Moreover, the fruit varies slightly according to locality, and develops local characteristics which have acquired for it distinctive local names; thus in Kyrenia District we have templiotiké and kyrionitiké, in the Karpas there is the sarakine (introduced by Saracens ?) and elsewhere the vaklitiké and kombotó. This bean or pod, which when ripe is of a chocolate colour, contains from 6 to 10 hard seeds, embedded in a sweet, pithy, honey-like substance which imparts the flavour so much appreciated by animals.

The carob tree belongs to the natural order Leguminosæ, sub-order Caesalpinæ, and is the only species of the genus *Ceratonia*. It is an evergreen, long-lived tree, growing to a height of 30 ft. and sometimes even to 50 and 60 ft. It thrives in most kinds of soil, especially in porous, marly and even volcanic soils, but not in marshy lands. Owing to its long tap root it resists drought well, and is to be found growing well in rocky land such as is common in many of the carob areas of Cyprus. It is very generally found intermixed with the olive tree and up to about the same altitude.

A succession of flowers is produced from July to September or October, and in favourable years up to December and even later, and in July–August the tree bears both flowers and ripe fruit. The collection of the latter commences about mid-August, the exact date being annually fixed separately in each district by the Commissioner. This is done in order to prevent the fruit from being stolen.

Recent investigations made by the Agricultural Department go to prove that the fruit-producing carob tree of Cyprus is really hermaphrodite, though there yet remains much room for investigation and the point is not finally settled. The others are true male trees. The

hermaphrodite carob trees which form practically the whole of the fruit-producing trees of the Island are cleistogamous (*i.e.* self-fertilised before the calyx opens) and short-stamened.

There are also certain trees self-produced from seed which are superior to the ordinary so-called wild tree. These bear fruit which is straight and short but more or less marketable, and these are known as "kountoura" (short) or "apostoliki," as though sent by chance or by Providence. The word "apostoliki" is applied in Cyprus to other kinds of trees or fruit showing similar phenomena.

There are several millions of these trees in the State forests, and yet more privately owned. It frequently happens that, owing to the wide powers of testamentary disposition, a single tree passes by inheritance to several heirs.

Many thousands of carob plants are annually raised in the Government gardens and issued at a trifling charge. The common method of propagation has been to sow the seeds in pots, and when the plant is from 18 in. to 2 ft. high it is ready for transplanting. The seed, which is very hard, is softened by placing it in a cauldron or saucepan of cold water. The water is then brought to the boil. On arriving at boiling-point the water is cooled and should then be changed and the seed left to steep for twenty-four hours. Owing to the long tap root, sowing in ordinary nursery beds has not been satisfactory, as the plants, which certainly make better growth than in pots, do not transplant well.

The foregoing methods have to a great extent been superseded by that of germinating the seed in damp sand and sowing direct in the field in properly prepared holes. Little watering is needed if the holes are deep and the soil kept friable. A top mulch is useful to conserve the moisture.

Transplanting from pots or beds is best done when the plants are twelve months old and about 12 in. high, after that it is precarious. Grafting may be done as soon as the stem is thick enough to take a graft, either before or after transplanting.

The tree is liable to attack by insects and other pests.

Scale (*Aspidiotus ceratoniæ*) is very common; but the greatest damage of late years has been caused by the fly *Cecidomyia ceratoniæ*, which lays its eggs on the flowers or newly-set fruit, and the grub feeds on the bean, causing it to become stunted and of no commercial value. This stunted condition is locally known as "brachycarpia" and has been the subject of careful scientific study and practical treatment by the Agricultural Department during the last few years. Very satisfactory results have been recorded from the campaigns, which have so far been limited to the Kyrenia District, and these have justified the extension of compulsory treatment to other infected areas. This and other pests, such as *Myelois ceratoniæ*, *Cossus liniperda* (a lepidopterous boring insect), a species of *Mycetiasis*, and a small hymenopterous fly which has lately appeared and is now under investigation, have, no doubt, checked production. The attacks of *Cecidomyia*, when serious, reduce the yield by 80 per cent. or over, and normally may lessen it by 40 to 50 per cent.

Much damage is also caused by rats (*Mus alexandrinus*), which gnaw the bark of the branches, causing them to dry up. Their destruction is encouraged by Government by the payment of 1 cp. per tail.

Carob gathering commences about mid-August and lasts for about a month. The beans are knocked down with long sticks, put into sacks and brought into store, or heaped up in the open air, where they often remain for several weeks. This is a safe procedure, as there is little rainfall at that season, and what might fall would not harm the beans, which would quickly dry again.

It is not easy to estimate the yield per donum of carob trees, but assuming that the trees were planted 30 ft. apart, and there were 16 medium-sized trees to the donum, the yield would average somewhere about 1,260 okes to the donum. The yield varies from year to year, a good year generally being followed by a moderate year. The fruit may be destroyed by frost in January and February, knocked off by hail-stones in March and April or scorched by hot winds in May or June. A full-sized, well-cultivated tree can give up to 720 okes. Taking good and bad years, the value of the annual produce of a medium-sized tree is 5s.

Carobs are sold by the Aleppo cantar of 180 okes, and the normal price may be put at from 13*s*. to 17*s*. per cantar delivered into store.

Carobs are weighed on export and the tithe is taken in money from exporters at the Customs House.

The following table shows the export of carobs during the ten years ending 1913–14:

Year.	Quantity. Tons.	Value. £
1904–05	31,887	104,301
1905–06	26,187	85,105
1906–07	44,965	157,452
1907–08	42,381	151,610
1908–09	57,010	188,841
1909–10	44,059	157,972
1910–11	37,485	145,590
1911–12	51,359	182,883
1912–13	63,658	251,750
1913–14	44,989	179,027

The falling-off in 1913–14 was mainly due to the losses caused by the fly *Cecidomyia ceratoniæ*.

The fruit of the carob is exported mostly to England, but also to France and Egypt, and more recently, before the war, to Germany. Gaudry mentions that about the middle of last century it was exported to Russia, Sardinia and Austria. Some is used, in Egypt and the Levant especially, as food for the poorer classes and for making sweets and sherbets. Its chief use in Western Europe is as food for animals, bovine and equine, for which purpose it is ground up and either made into meal or cattle cakes. It is also said to be employed in the manufacture of chocolate and spirit, and there is a demand for the seed for use in the manufacture of certain gums.

The juice of the bean, "carob honey," locally called "mavromelos," "teratsomelo" or "betmezi," is consumed as a substitute for bee-honey or jam and also as a flavouring for culinary purposes. From the carob honey is also made the sweetmeat "pastelli."

At one time carobs were used in Cyprus for fattening mules and other animals, but, unfortunately, this practice died out. Efforts are now being made to revive it, and the advantages of this local product are again becoming recognised.

The carob contains some 50 per cent. of saccharine matter and the interesting question has been raised in recent years as to whether the bean might not become a new source of sugar production.

Lucerne (*Medicago sativa*)

This plant was introduced about eighteen years ago, but in spite of its undoubted success when properly grown on suitable soil, the Cypriot farmer was for many years very slow to make use of it. Every effort has been made of late years to encourage its cultivation and during the last three or four years there has been a steadily increased demand for seed. Irrigation is necessary in order to obtain a satisfactory yield, but there are many farms where it might be grown with great advantage. Its value for cattle food is generally recognised, and now that greater attention is being given to dairy cattle, lucerne would seem to have an assured future,

Vetch (*Vicia Ervilia*)

This plant, known locally as "rovi," is undoubtedly the most widely grown of the fodder crops. Being a leguminous plant, it has a restorative action on the soil, although the average Cypriot farmer still considers it to be exhaustive.

In the plains sowing begins in January, whereas in the Pitsillia, and even in the Morphou, Solea and Tylliria districts which are only at the foothills, it is sown in October–November, *i.e.* before the cereals.

Rovi is almost the only food in the form of seed given to ploughing oxen throughout the East. It is regarded as heat-giving and strengthening, and is therefore fed specially in winter. It is sometimes given unthreshed with the straw. It is harvested in May, when it is uprooted, made into little bundles, which are stacked together in small heaps in the field, until they turn yellow, when they are removed to the native threshing-floor and threshed in the customary manner. The dry stems, etc., are eagerly eaten by cattle and sheep. The average yield is very little, from 2 to 4 or 5 kilés per donum. It is subject to tithe.

Chickling Vetch (Lathyrus sativus)

The chickling vetch, known locally as "favetta" or "chavetta," has come rather more into prominence of late years, displacing the vetch (*Vicia Ervilia*) to some extent, as it gives a heavier yield. It is subject to tithe.

Vetch (Vicia sativa)

This crop, called locally "vicos," was introduced from Crete in 1913 and has been found excellently suited to this country. It is most useful in any rotation, and has to some extent supplanted rovi (*Vicia Ervilia*) as it gives a larger yield. It is a most nutritious cattle food, for which purpose it is grown. When crushed and mixed with chopped straw it is readily eaten by cattle and sheep. The plant seeds itself very freely. It is sown about November–December and is ready for harvesting in about April. Seed is sown at the rate of 5 to 6 okes per donum and the yield is normally from 8 to 12 kilés per donum. It is a good drought-resister and needs no irrigation, and being a leguminous plant should be cut and not pulled up, as the roots left in the soil serve to increase the amount of nitrogenous salts. Being a vetch it is subject to tithe.

Tares (Vicia tenuifolia var. *stenophylla)*

This plant, locally called "mavracheron" or "phakacheron," grows wild in the Pitsillia district among the vineyards and other cultivated as well as uncultivated lands. It is of value in those remote localities where grain and straw are little grown and difficult to procure, as it provides a wholesome fodder for cattle. The villagers have now taken to cultivating the plant. It is cut before the seeds are fully matured to prevent loss of seed through shedding. The seeds and chaff are mixed together when fed to cattle.

Milk Vetch (Astragalus)

This plant, locally called "arkokoutsia," grows wild in some abundance among the hills. When it appears above ground it is readily eaten by animals, especially sheep;

but at this stage it is apt to cause hoven. As the plant hardens the animals do not touch it, except when fully ripe, and then it is greedily eaten.

As soon as it blossoms, but before the fruit is set, the plant is gathered and tied into bundles or small sheaves and stored in a heap. When, after a few months, it is quite dry, and at a time when other foods are scarce, it forms an important part of an animal's ration.

The plants are sometimes allowed to mature their seeds, and these, after being steeped in water for two or three days to remove acidity, are given to pigs, and are considered a nourishing and palatable food.

Moha, Sulla (Hedysarum)

These have been tried for some years with success and are gradually becoming known and experimentally grown by farmers.

Teosinte (Reana luxurians)

This grass is one of the most valuable fodder plants with which the New World has enriched the Old. It is a native of Guatemala and is also largely grown in Australia.

Seed was first imported into Cyprus by the Agricultural Department in 1897, and since then the plant has been continuously grown in the Government gardens with marked success. It is sown in March–April in the same manner as Indian corn, to which it is allied.

If irrigated, three or four cuttings may be obtained during the summer, yielding 25 to 30 tons of green food per scala. It is greedily eaten by cattle. Some plants grown by the Department attained a height of 11 ft. 3 in. and of others which were left to ripen their seed, one had 93 stems and weighed 26 okes, though the leaves had begun to shrivel and had lost weight.

This plant is gradually becoming known and may be found growing on some of the more progressive farms.

Sudan-grass

Seed of this fodder grass was imported in 1915 and very satisfactory crops have been obtained each year since

then from the experimental plots. The grass seems well suited to Cyprus and gives a useful yield even when unirrigated. Occasional irrigation produces a valuable crop. Trial sowings are now being made on a few private farms.

Teff-grass (*Eragrostis abyssinica*)

This has also been tried experimentally with good results and it is hoped that its cultivation will extend as it becomes more known.

Mangold Wurzel

This crop has been grown for several years at the Government Farm, Athalassa, where it has done well and forms an important part of the cows' rations. It has been grown successfully on a small scale in some of the Nursery Gardens.

As irrigation, deep ploughing, thorough cultivation of the soil and special cultural operations are needed, this crop cannot be generally recommended to farmers, but it is being grown by a few progressive stock owners under Departmental advice.

The wild beet (*Beta vulgaris*) is a native of the sea-coasts of South-eastern Europe, and the garden beet-root is much grown in Cyprus in certain localities, so, if carefully cultivated, mangold wurzel, which is a variety of *B. vulgaris*, might also do well in many parts and be of great advantage to stock owners.

Prickly Pear (*Opuntia*)

The prickly pear grows wild as a hedge plant in Cyprus. The fruit is eaten to some extent by villagers, but no attempt has yet been made to use the stems as food for animals. In Sicily very large quantities are so utilised, and now that milch cows are coming more into demand in Cyprus the value of the plant for fodder may become recognised. Successful experiments have been made by the Agricultural Department in mixing the juice of the stems with lime for giving brilliance and permanence to ordinary whitewash. There has been an occasional export of the fruit to Egypt for consumption by Arabs.

Spices

Coriander Seed

Coriander seed is the product of *Coriandrum sativum*, Linn., an annual herb belonging to the natural order Umbelliferæ. The "seed," or more strictly fruit, of the plant is employed in confectionery in making bonbons, in the preparation of certain liqueurs and as an ingredient for disguising the taste of medicines. In Cyprus it is commonly used as a flavouring in cooking.

A sample sent to the Imperial Institute in 1917 was examined as a source of volatile oil, and the residue remaining after distillation was analysed as a feeding-stuff. On steam distillation the ground seed yielded 0·48 per cent. of an almost colourless volatile oil with the characteristic and pleasant odour of coriander. This yield is below that furnished by Russian and German coriander, but is about equal to that obtained from Morocco seed. The results of the examination indicate that the residue has a fairly high feeding-value, and it would be quite suitable for the ordinary use of coriander residue, *i.e.* as a cattle food.

A sample of the seeds was submitted to brokers in London, who reported that they were very stalky, but that their value would be from 50*s*. to 60*s*. per cwt. (January 1917) as compared with 10*s*. to 15*s*. per cwt. before the war. (see Bulletin of the Imperial Institute, vol. xv. 1917, p. 301).

Aniseed

Aniseed, the fruit of an umbelliferous herb (*Pimpinella Anisum*, Linn.), is grown on a comparatively small scale in Cyprus, the exports in recent years varying from 1,000 to 2,000 cwts. per annum. In 1917, 1,015 cwts., valued at £3,164, were exported, all of which went to Egypt.

Seed sent for examination to the Imperial Institute was reported to consist of aniseed in good condition and practically free from extraneous matter.

A sample of the seed was submitted to brokers in London, who stated that at that time (January 1917) stocks of aniseed were quite exhausted, and the prices

therefore much inflated, small stocks of Spanish aniseed having changed hands in London at 110*s.* per cwt. Such price could not be secured if any quantity of aniseed were placed on the market. The value of the Cyprus sample before the war would have been about 27*s.* 6*d.* per cwt. (see BULLETIN OF THE IMPERIAL INSTITUTE, vol. xv. 1917, p. 300).

White Cumin Seed

White cumin is also an umbelliferous herb (*Cuminum Cyminum*, Linn.); an account of the cultivation and uses of this and other spices is given in the BULLETIN OF THE IMPERIAL INSTITUTE, vol. xi. 1913, pp. 131–136.

A sample of the seed sent to the Imperial Institute was submitted to brokers in London, who stated that it was rather small and stalky, but that it would probably be worth between 70*s.* and 80*s.* per cwt. (January 1917), although they were of opinion that its pre-war value would not have been much over 20*s.* per cwt. (see BULLETIN OF THE IMPERIAL INSTITUTE, vol. xv. 1917, p. 302).

Black Cumin Seed

These seeds, sometimes known as fennel-flower seeds, are the product of *Nigella sativa*, Linn. (Nat. Ord. Ranunculaceæ). The plant is an annual, native to the Mediterranean region, and the seeds, which are used in the East for flavouring curries, etc., and in Egypt as comfits on cakes, have an aromatic fennel-like odour when fresh and a slightly acrid taste. There is a small export of black cumin seed from Cyprus. There is, however, but little demand for this seed (see BULLETIN OF THE IMPERIAL INSTITUTE, vol. xv. 1917, p. 304).

ESSENTIAL OILS AND PERFUMES

Origanum Oil

Different opinions have been held as to the botanical identification of the plant from which the Cyprus origanum oil is produced. An interesting series of articles on this subject by E. M. Holmes appears in the *Perfumery and Essential Oil Record*, 1913, from which it would seem that

this oil is derived from *Origanum majoranoides*, Wild.; while Dr. Stapf, of Kew, regards the plant as *O. dubium*, Boiss. (see BULLETIN OF THE IMPERIAL INSTITUTE, vol. xi. 1913, p. 50). Other varieties growing wild in Cyprus are *O. Onites*, *O. hirtum*, both of which are locally called "rigani," *O. Bevani* (see BULLETIN OF THE IMPERIAL INSTITUTE, vol. xv. 1917, p. 305) and *O. majorana*.

In its wild state the plant from which origanum oil is distilled is a small perennial shrub, but, if cultivated, its size may be doubled or even trebled. The first crop, consisting of shoots and flowers, may give from 300 to 500 okes per donum; in subsequent years up to 1,000–1,500 okes per donum. The latter quantity would produce 40 to 60 okes of origanum oil, which is largely used in England for perfuming soap and other purposes.

For twenty years the distillation of origanum oil has been made under Government control. The industry was started in 1899 and, though not large, has steadily grown. It has been found that the Cyprus origanum oil is exceptionally rich in carvacrol (over 80 per cent.), a powerful antiseptic, and to this substance the oil owes mainly its characteristic thyme-like odour. Frequent analyses have shown that the Cyprus origanum oil is remarkably constant in character.

This oil has the slight disadvantage of darkening considerably on exposure to light and air, which renders it unsuitable for use in light-coloured soaps, but a method has been worked out at the Imperial Institute of refining the oil so as to yield a product which will remain practically colourless for long periods.

A report furnished by the Imperial Institute (BULLETIN OF THE IMPERIAL INSTITUTE, vol. iv. 1906, p. 299), after giving a detailed description of the oil, states:

"The foregoing results show that this oil sells readily in this country at prices which should be fairly remunerative to producers in Cyprus. It should, however, be borne in mind that the demand for this oil is somewhat limited, and that it competes with the thyme oil produced in France and Spain, and with the 'origanum oil' produced in Smyrna, and that consequently a sudden increase in production in Cyprus might lead to a considerable fall in

price. The Cyprus oil has, however, the advantage that it is very rich in the odorous and antiseptic constituent carvacrol, and it is probably due to its richness in this constituent, as revealed by the analyses made at the Imperial Institute, that the comparatively high prices realised for these consignments were obtained at a time when 'red thyme oils' were selling at lower rates. It would be advantageous if a refined white oil could be prepared by some simple method from this material, as this probably would fetch an enhanced price, and be applicable to other purposes for which the 'red oil' is unsuitable."

Until 1910 the distillation was made by the Department, but since then it has been undertaken by private contract, permission being given to collect the wild plant from the forest. The annual production is now about 2,750 lb., and the price has steadily risen from about 3*s.* per lb. to 8*s.* 6*d.* per lb. at the present time. But whereas the cost of transport to London before the war was £8 per ton, it has risen to the prohibitive rate of £200 per ton, and the 1917 oil still remains in store at Alexandria.

The supply of the wild plant is limited and its cultivation is under consideration.

The following table shows the exports of origanum oil in recent years:

Year.	Quantity. *lb.*	Year.	Quantity. *lb.*
1902	2,092	1911	2,276
1903	No distillation	1912	2,230
1904	2,410	1913	2,455
1905	1,463	1914	3,776
1906	2,200	1915	3,709
1907	1,745	1916	2,756
1908	2,051	1917	2,696
1909	1,530 [1]	1918	2,066
1910	2,842		

[1] *A quantity of stored plant was destroyed by fire, reducing the output.*

Marjoram Oil

This is not yet a regular product, but samples of locally produced oil have been examined at the Imperial Institute and pronounced to be superior to European marjoram oil and about equal in value to sweet fennel oil (see BULLETIN OF THE IMPERIAL INSTITUTE, vol. xi. 1913, p. 50). It is

distilled from a plant which is abundant in the forests of Kyrenia and Paphos, and which has been referred by Dr. Stapf to *O. majoranoides*, Wild., and by Mr. Holmes to *O. Maru*, Linn. The market is, however, restricted.

Laurel Oil

Samples of oil distilled from the leaves of *Laurus nobilis* which were examined at the Imperial Institute were found to have an aroma inferior to that of the oils usually met with in commerce (see BULLETIN OF THE IMPERIAL INSTITUTE, vol. xi. 1913, p. 430). The demand for the oil is said to be small.

Otto of Roses

This has been prepared since 1897 in a very small way with native stills at the village of Milikouri, where the Damask rose is abundant. The cultivation of this rose has now spread to other hill villages. The closing of the market for Bulgarian otto of roses owing to the war has given an impetus to the industry in Cyprus. The Agricultural Department has for two years sent qualified officers to superintend the work at Milikouri and to carry out an experimental distillation.

A report from the Director, Imperial Institute, upon samples of the 1917 distillation states that " the constants of the Cyprus oil agree closely with those recorded for Bulgarian otto of roses." It was found that the odour of the Cyprus oil was fairly good, but rather weak. The otto sold at 70*s*. per ounce, less 2½ per cent., which " in view of the very small quantity must be considered satisfactory." At the time of sale French otto was quoted at 78*s*. to 85*s*. per ounce.

Acacia Farnesiana

This tree is but sparsely represented in Cyprus, but wherever found it is vigorous and healthy. It belongs to the Mimosa tribe of the order Leguminosæ and, as other species are common in the Island and thrive remarkably well, there would seem no reason why this species also should not become more general.

It is known elsewhere under different names; that of "sweet briar" (in Barbados) on account of its numerous thorns and the exquisite scent of its flowers, and "stinking cossie" (in Antigua) owing to the highly disagreeable smell of its wood. The word "cossie" may be a corruption of acacia.

Its flowers are largely used in perfumery, and the annual crop of the flowers of this plant in France is stated to be worth thousands of francs, and a particularly delicate fragrant perfume is extracted from them. The pods are said to yield a fair amount of tannin, while from the cracks in the bark of the trunk and branches there exudes a gum very like the true gum arabic and is utilised for the same purpose. The wood makes good charcoal.

It is locally known as "skouroupathos" or "skouroupathia," and is closely allied to the extremely common weed of that name which is found abundantly in nearly every field in the plains during summer, but which, owing to its deep-rooted system, the natives do not trouble to eradicate. It is also allied to *Prosopis juliflora* or algaroba tree, of which there are a few specimens in the Island.

Oils and Oil Seeds

Olives

The olive tree grows wild in Cyprus, but the wild fruit is small and bitter and yields an inferior oil. The cultivated trees are those which have been grafted. Owing to the stringent regulations which have prohibited the introduction of living plants from abroad, it has not been possible to obtain from elsewhere good grafts of new varieties. These regulations have lately been modified to allow of importations by the Agricultural Department under special restrictions, and now that the war has ended it is hoped to obtain these much-needed olive grafts.

This tree thrives well, almost all over the Island, up to an altitude of about 2,300 ft., and numbers of vigorous wild olive trees are to be met with, which only need cleaning and grafting in order to bear fruit.

Cyprus olives are divided into two classes, locally known as (*a*) "adrouppes" or "drouppes," which are eaten in

Pruned Olive Trees at Metochi of Kykos.

the green or black stage, and (*b*) "ladoelies," which are suitable both for eating and for oil extraction.

Of the former, or "adrouppes," one kind is rather large, with rough skin, having a rough, big stone, the other is longer but of less diameter, and has a very thin, smooth skin and the stone is smooth, curved and smaller. The latter has a better taste and resembles the well-known Greek olive of Calamata. Both these "adrouppes" are prepared for the table while still green, and are known as "kolymbates," or sometimes they are called "tsakkistes," owing to the stone being slightly crushed in the process of preparation.

The "ladoelies" are of two distinct varieties, the larger of which is mostly regarded as an edible olive, and contains a less percentage of oil, while the other, or smaller kind, is richer in oil contents, and is mainly used for oil production, though it is sometimes eaten.

A few imported varieties, including one or two specimens of Spanish and Greek olive trees, are to be found here and there in private gardens.

If the land were manured and ploughed the trees would, especially on the chalky soils, yield abundant fruit and oil of excellent quality. Unfortunately this is not done, and it has been found very difficult to induce the peasants to adopt any kind of cultivation. They plough the land only when they intend to sow corn or other crops between the trees, a procedure which tends to lessen the productiveness of the trees. The system of irrigation applied is also very defective. Irrigation, while improving the quality and quantity of edible olives, is not desirable in the case of press olives.

As to pruning, Cypriots would have none of it until within the last five years. By dint of patient and constant persuasion, some few of the larger owners were induced to let their trees be pruned by a staff of pruners under the direction of the Agricultural Department (see Plate VI). Much ridicule—and at times threats—was hurled at both the pruners and the tree owners, who were assured by the villagers that for their folly they would undoubtedly lose their trees. The results belied all these fears, and now within the space of some four to five years the practice

of pruning has become fairly general, and a good number of villagers have qualified themselves as expert pruners and are kept regularly employed by private persons. As a consequence of this a great amelioration is noticeable in the olive trees in many parts and the yield and quality of olives have been improved.

The method of gathering olives by beating, however, continues. The fruit so knocked to the ground becomes dirty and bruised, and quickly ferments, when stored, to the detriment of the oil. This mode of gathering by beating damages the young twigs and branches, whose bearing capacity the following year is thus impaired.

Little care is taken in selecting the olives for oil. Not only are they dirty and bruised, but unripe or diseased fruit, as well as overripe fruit that has fallen from the tree, is collected together indiscriminately.

The usual practice is to spread out the olives as received, and unsalted, on the mud roofs of houses in order to give off a part of their water before grinding.

The procedure is then as follows:

They are first of all taken to the crusher or grinding mill. This consists not of two stones, as in Greece, but of one stone, drawn by pony, mule or donkey.

For the first quality of oil the olive stones should not be broken, but generally speaking, insufficient care is paid to this and the stones are, for the most part, crushed. The crushed olives (zimari, paste) are then removed to the press, which is worked by hand, with one exception of an hydraulic press at Akanthou. At this village, where the best olive oil is produced, the olives are brought direct from the trees to the mill, whereas elsewhere the practice is to leave them in a heap to ferment and they often become foul and covered with dust and dirt.

In pressing with wooden presses, the zimari or crushed olives are placed in round bags made of plaited rushes. Seven to ten of these are placed one on top of another in the press and the oil obtained is virgin oil (huile vièrge).

The bags are then removed and squeezed so as to change the position of the contents. They are then replaced in the press and hot water is poured into each bag. The oil

obtained is of second quality. A third pressing is sometimes given.

The yield is calculated at the rate of 1 oke of oil to 4 okes of olives.

In the Paphos district is produced a black oil with a very distinct flavour. This is due to the custom of boiling the olives before grinding. The demand for this inferior oil is confined to that district.

In former days it was usual for the mills and presses to be worked in the open. This is now rarely the case, but may still be occasionally seen in parts of the Paphos district and elsewhere.

Whether outdoors or indoors these mills and presses are soon allowed to become very unclean, and the rancid flavour which clings to the wood is quickly imparted to the oil, which possesses, for any but Cypriots, a strong and unpleasant smell and flavour. There is a considerable residue or waste, which, if it could be utilised, would go far to meet the deficiency in the requirements for local consumption.

There are a few good iron presses now in use. Their superiority is generally recognised and, no doubt, now that the war is over, they will be imported in greater numbers.

Small inexpensive, cottage filters have been designed by the Agricultural Department and these are being adopted, though very gradually. The oil so filtered is greatly superior, but having acquired a more delicate flavour, it is not so much appreciated by the native consumers.

Large numbers of young wild olive trees are issued on permit from the State forests for private cultivation and many thousands of two- and three-year-old plants raised in the Government Nurseries are also distributed every year. With the gradual improvement in cultivation and in the preparation of the oil, the production should increase enormously.

The local production of olive oil is insufficient for the requirements of the Island, but there is no reason why, in the course of time, when the large number of trees newly planted and annually on the increase, come into bearing, a valuable export trade should not result. The figures of production, given in the table below, are strikingly

fluctuating, and indicate the irregularity of the annual yield and the marked variation in price:

Year.	Quantity. Cwts.	Value. £
1904	4,294	6,467
1905	5,291	8,504
1906	7,845	12,602
1907	8,981	16,922
1908	788	1,459
1909	3,851	8,864
1910	7,550	17,232
1911	608	1,415
1912	48	88
1913	911	2,052
1914	2,197	4,837
1915	6,003	15,146
1916	4,966	16,035
1917	290	1,225

Sesame Seed

The annual production in Cyprus of sesame seed (*Sesamum indicum*) is said to be about 195,000 okes. It is one of the recognised summer crops in the plains, and is frequently sown together in the same field with cotton, maize, etc., and in the vine villages it is sown in the newly planted vineyards, where it does well. In such cases the preparation of the soil is done on the same lines as for cotton, maize, vines, etc.

The seed is used mainly for the extraction of the oil which is largely employed in cooking, and it is also used in the preparation of sweetmeats; it is added sometimes as a condiment in bread-making. There is a small export, principally through Egypt.

The percentage of oil extracted varies according to the locality where the seed has been produced. Of the local product, that from Paphos gives the highest yield, viz. 30 to 35 per cent.; but this is inferior to the Egyptian product, which is to some extent imported and yields 40 to 45 per cent. of oil, this being probably due to the thinner skin. The crop is uncertain. The plant is readily affected by the hot west wind (*λίβας*) which not infrequently blows during its period of growth. The development of the seed is thereby checked and it remains thin and small (*ψάλιος*), and naturally the oil yield is diminished.

Ground Nut, Peanut or Monkey Nut (Arachis hypogæa)

This nut is fairly popular among all classes and is imported through Egypt in moderate quantities. There is no reason why in certain localities this plant should not be grown successfully, more especially in the light sandy soils around Varosha and at Syrianochori. Efforts have been made to induce cultivators to grow this crop, but so far it has not commended itself. It calls for something a little out of the ordinary in the way of cultivation, as the plants mature their fruits under the soil; the profit to be derived from the crop is uncertain, and is thought, though without sufficient proof, to compare unfavourably with rival crops. Growers have been somewhat deterred by the ease with which the fruit can be stolen. As this is hidden under the soil, a theft is not at once detected. These drawbacks probably explain its restricted cultivation.

Should oil-extracting machinery be introduced, these nuts might well be grown for their oil, both for culinary purposes and for use in soap-making. The residuum, after extraction of the oil, and the haulm are nutritious cattle foods.

The importation of these nuts was recently prohibited except in a roasted condition, owing to the risk of their introducing plant pests when in the raw, earth-encrusted condition. This has tended to check importation, and may perhaps give an impetus to local production. Ground nuts can be grown, of course, only where irrigation is possible.

The quantity of ground nuts imported in 1917 was 1,532 cwts., valued at £2,448. Previous to that year they were not separately enumerated.

Castor-oil Seed

The castor-oil plant (*Ricinus communis*) is only grown to a small extent, but the tree usually thrives well and its cultivation might be extended with advantage. According to Gennadius, Dioscorides claimed that it used to be called Seseli of Cyprus, from which the inference may be drawn that the plant has long been among the flora of the Island, where it is now known as a perennial. It grows

very freely from seed and rapidly attains a height of 15 or 16 ft.; but it quickly dies back after a slight frost, though it recovers again the following year. It appears to do well in most soils, but thrives best in light loam with moderate moisture.

Owing to the demand for the oil, one or two plantations have lately been made by the Agricultural Department.

The varieties locally grown include plants producing large, medium and small-sized seed. Trial cultivations are being made to ascertain their relative values. It is found that a heavier yield of better quality is usually obtained where the plant is treated as an annual and not as a perennial. Four samples of castor seed examined at the Imperial Institute were found to contain normal amounts of oil, and similar seed would be readily saleable in the United Kingdom if offered in commercial quantities (see Bulletin of the Imperial Institute, vol. xvii. 1919, p. 492).

Fibres

Cotton

During the time of the Venetian occupation (1489–1570) Cyprus exported annually from seven to fifteen million pounds of raw cotton. In the seventeenth and eighteenth centuries the English Levant Company sent large quantities from Cyprus to England. When the scarcity of cotton occasioned by the American Civil War gave a stimulus to its growth Cyprus took part in meeting the demand, and in 1866 over 2,000,000 lb. were exported. Since then the production has declined. In former times, then, the production of Cyprus cotton must have been very large, as cotton manufactures in the Island were, as in most cotton-producing countries in the East at that period, both considerable and of choice quality. Cyprus was always distinguished for its cotton spinning. Gennadius suggests that the Karpas, which is one of the centres of the Cyprus cotton manufacture, derived its name from the ancient "karpasos," a fine cotton cloth which came from India. There is an old Hebrew word

" karpas " found in the Old Testament, and derived from the Sanscrit "karpasa," cotton, or "karpasum," cotton cloth.

During the Turkish Administration cotton cultivation declined, owing to the destruction of aqueducts, Venetian wells, etc., and to the practice of taxing the cotton crop in the field before it was picked—a cause of considerable delay and detriment to the crop. Careless cultivation and consequent deterioration of the fibre as well as the general fall in value contributed to the decay of the industry. Taxing the crop in the field was abandoned in 1890, and a tithe was levied on exported cotton only (*Handbook of Cyprus*).

The species of cotton principally cultivated in the Island is *Gossypium herbaceum*. American " New Orleans " seed was introduced some twenty years or so ago, and this has now largely displaced the original native kind; in fact the native kind has almost entirely disappeared, and what little is grown is mostly used for stuffing the native bed-quilt or " paploma."

Cotton grown without irrigation is known as " dry " cotton. It is grown chiefly in the Messaorian plain and in the Karpas; it is harsh to the touch and short in staple, but of satisfactory colour. " Wet " cotton is grown on irrigated land; it is usually of larger staple and of finer quality than the " dry " cotton and commands a higher price. This is grown mainly round about Kythrea, Nisou, Dali, Lapithos and in the Solea valley. Native cotton is always grown " dry "; the ordinary American variety is grown both " wet " and " dry."

The Karpas cotton, which is " dry " grown, is inferior not only on account of its shorter staple, but on account of the method of picking. In some places of Messaoria, at Dali, Nisou, etc., the " dry " and sometimes the " wet " cotton is picked in the morning before the dew has quite evaporated, and it is picked direct from the growing plant. But the most general practice is for the villagers to cut the bolls early in the morning before the dew is evaporated (*πορνή*), transport them to the houses and then remove the lint at their leisure. In this way the bolls are more or less crushed and the lint when removed contains a mixture of husk, leaves, etc.

In the case of native and other varieties the lint of which adheres to the boll, the husks, leaves, etc., are removed from the bolls in the following way: The bolls are spread out on mats to dry in the sun; when sufficiently dry the bolls are put in a rotary sieve made of reeds and sticks, similar in make to the ordinary reed baskets of the country. Each end of the sieve is closed, but it has an opening in the middle, about 1 by 1½ to 2 ft., which is closed by a small reed mat. The sieve is about 5 to 6 ft. long and 2 to 2½ ft. in diameter. The bolls are dropped into the sieve through the opening and it is then revolved by hand by means of an axle which passes through it longitudinally. By this means most of the crushed husks and leaves fall through the interstices of the sieve.

The native seed is usually grown on dry lands as it withstands drought. The "wet" cotton is mostly of the American variety.

Professor Wyndham Dunstan, F.R.S., in his *Report on the Agricultural Resources of Cyprus* (1905), referred to the sucessful trials made with "Sea Island," "Peterkin," "Truitt's Big Boll," "Culpepper Big Boll," and "Allen's Long Staple." Since then other varieties have been tried by the Agricultural Department, and while "Allen's" and "Truitt's" have continued to do well, good results have been obtained from "Triumph" and "Durango," both of which are early kinds and are therefore very suitable to the Island. A report by the Imperial Institute on samples of "Allen's Improved," "Mebane's Early Triumph" and "Sakellaridis" cottons grown experimentally in Cyprus in 1915 will be found in the BULLETIN OF THE IMPERIAL INSTITUTE (vol. xv. 1917, p. 298).

Owing to fear of locusts, late sowing (about May–June) became rather general. This is a dangerous practice as the bolls ripen late and much cotton is spoilt by the early autumn rains. It is mostly sown broadcast or in trenches; on irrigated land it is mostly sown in the ridges, but the older practice of sowing broadcast still, unfortunately, continues.

"Dry" cotton is usually sown either on land which can be irrigated by a river when in flood, or in "livadhia" or

low-lying lands which retain their moisture a long time. In the former case the seed is sown about March-April, while the soil is still damp from rain water or from river overflow. It is generally expected that when the young plants are fairly established a second irrigation from flood-water may occur. In the "livadhia" the seed is sown later. "Wet" cotton is watered about every fortnight.

The crop begins to be collected in mid-September and continues up till the end of October. "Dry" cotton is rarely manured; "wet" cotton occasionally. The use of chemical manures is coming into practice. There are several ginning machines in the Island, but baling by hydraulic presses is done almost exclusively at Larnaca.

In the Island the cotton seed is used for sowing and for feeding cattle. The exports of cotton seed have been:

Year.	Quantity. Cwts.	Value. £
1909	2,708	769
1910	3,066	970
1911	3,245	830
1912	15,874	4,535
1913	13,933	3,750

The exports represent about three-fourths of the total production.

There should be a good opening for machinery for extracting the oil.

The cotton is locally graded into (1) best, (2) medium, and (3) poor, all being American varieties. The first quality is the "wet" or irrigated cotton. The second quality is grown mostly in the Messaoria plain and at Dali, Nisou, Potamia, Kythrea, where it is partly irrigated by river floods. The third quality is "dry" and comes principally from the Karpas. On the Marseilles market the second quality has a value 3 to 4 per cent., and the third quality 8 to 10 per cent. less than the first quality. The first quality ranks in price at Marseilles on about a level with American cotton.

For some ten years Greece has taken the leading place as an importer. Before the war, Cyprus cotton went chiefly to Marseilles and Greece, some also to Trieste.

Only a very insignificant quantity goes to England. The freight to Marseilles was about 25*s*. per ton, to Trieste about 15*s*. per ton, while to England it averaged 50*s*. per ton. The market prices at Marseilles and Trieste were approximately the same, but at Marseilles they were subject to a discount of 1½ per cent., whereas at Trieste a discount of 3 to 4 per cent. was made. The Trieste market, being small, was subject to sudden fluctuations and was therefore risky and less favoured by Cypriot exporters.

For several reasons the Liverpool market has not been so attractive as that of Marseilles. At Liverpool and Manchester quantities of not less than, say, 100 bales are preferred, whereas Marseilles would take smaller consignments of 20 or 40 bales. Uniformity of type is required by Manchester spinners, whereas the French factories are more ready to handle different types, including the shorter staples. Cyprus merchants make no distinction as regards the varieties of cotton, whether "Orleans," "Sea Island" or other kinds, and indeed they are scarcely competent to do so, as this requires special knowledge and experience. They buy in small quantities from many peasant growers and mix the produce in order to make up a fair consignment.

In normal times there was always the further difficulty of obtaining direct transport to England, whereas to Marseilles, Trieste and also to Greece the opportunities were more frequent.

Since the war Greece has become much the largest buyer. Owing to shortage of cotton on the Greek market this commodity was purchased from Cyprus rather than from Liverpool, as the freight was lower and war risks much less; apart from the almost impossibility of obtaining tonnage. It was the practice before the war for Cypriot merchants to sell c.i.f. Piræus, but they could not continue this under recent conditions and now sell f.o.b. Cyprus, and this practice is likely to continue. This f.o.b. Cyprus price has lately been about the same as would ordinarily be obtained for c.i.f. Liverpool. Greece has many small filatures willing to take consignments of even 10 bales, and the shipment direct or via Alexandria is easier.

A Cyprus bale weighs about 150 okes.

The following figures, showing average annual exports of raw cotton at various pre-war periods, indicate the course of the cultivation :

Period.	Average Quantity. Cwts.	Average Value. £
1880–89	68,410	147,683
1890–99	57,291	91,812
1900–09	41,121	92,939
1910–17	68,384	213,275

Prices have varied, as is shown by the values of the following record years :

	Quantity. Cwts.	Value. £	Average price. £
1885 (highest export on record)	14,276	29,567	2 1 5
1886 (2nd ditto)	13,887	26,535	1 16 11
1912 (3rd ditto)	13,808	40,085	2 18 0
1913 (4th ditto)	13,444	40,693	3 0 6
1884 (5th ditto)	12,227	26,874	2 3 1

In 1917 there were 13,685 donums under cotton cultivation.

It is usual in some parts of the Island, especially in the Kyrenia district, to leave the crop in the ground for two or three years. This method of cropping is locally known as "palia" or old. It is found profitable to leave the cotton plants two or three years on irrigated land. The second-year crop usually gives the heaviest yield.

The average yield of unginned cotton on irrigated land is about 120 okes (3 cwts.) per scala ; but as much as 250 okes can be obtained. "Wet" cotton, best quality, yields 1 oke of lint from 3 okes of unginned cotton, and "dry" cotton yields about 1 oke of lint from 3½ okes of unginned cotton.

There is much land well suited to cotton which for lack of water cannot be utilised. If artesian water could be found, there would be a very considerable extension of this cultivation.

There is a well-equipped little cotton factory at Famagusta, and excellent cotton fabrics are made, especially in Nicosia neighbourhood, Lapithos and Karavas, Lefkonico and Gypsos and in the Karpas. These are known under

the names of "alaja" and "dimita." They are mostly of good patterns, the material is strong and wears well, and is being largely used, not only by the peasantry, but also for making men's suits and ladies' skirts and cloths.

An interesting article on the Cyprus Cotton Industry is to be found in the BULLETIN OF THE IMPERIAL INSTITUTE, vol. iii. 1905, pp. 327–334.

Flax and Linseed

The cultivation of flax (*Linum usitatissimum*), which began to develop some twenty years ago, has declined during the last ten years or so. The reasons for this are that it is considered to exhaust the soil, the later handling of the crop for fibre is troublesome and the market is liable to rather violent fluctuations. It grows well in the Messaoria plain, and when chemical manures are more generally used it may come more into favour. Attempts have been made to improve the quality by the introduction of Riga flax seed, but so far without success. There is a small export of linseed, but owing to the primitive methods of winnowing and cleaning it does not fetch the best price. The quality of the cleaned seed is excellent. Knowledge and care are needed in picking the crop at exactly the right time. The imperfect methods of general cultivation prevent the uniform ripening of the seed, and this means an uneven and unsatisfactory sample. Defective screening accounts for the presence in excess of foreign substances, weed seeds, etc. These difficulties are capable of remedy, and it may reasonably be hoped that when once overcome the cultivation will be extended.

In Cyprus the cultivation is the same whether intended for seed or fibre, and consequently the latter is of an inferior quality, as is indicated in a report on Cyprus flax published in the BULLETIN OF THE IMPERIAL INSTITUTE (vol. vi. 1908, p. 4). Seed is sown in November–December at the rate of 17 to 22 okes per donum. Retting is done by steeping in the large stone irrigation tanks which are a feature on most farms. In the Messaoria, about Ano and Kato Zodia, where flax is commonly grown, the plant is retted in the river Ovgos, which retains sufficient water

usually until August. The yield per donum varies from 100 to 300 okes of seed, 80 to 100 okes of fibre and 50 to 70 okes of tow.

Wool

The exports of wool for the three last pre-war years were as follows :

Year.	Quantity. *Cwts.*	Value. £
1911	5,535	13,452
1912	4,627	11,362
1913	4,707	12,181

This went chiefly to France, and next, though in much smaller quantities, to Italy.

The wool is of moderate quality ; this is partly due to the breed of sheep and partly to the conditions under which they are kept. Attempts have been made by the Agricultural Department to impress on the native breeders the necessity of keeping the sheep well fed, and experiments have been carried out at the Athalassa Experimental Farm for the purpose of demonstrating the advantages of careful rearing.

Two fleeces from the Athalassa Farm were sent to the Imperial Institute in May 1912, for examination and commercial valuation. One was the fleece of a yearling ram. This was clean, fairly soft and almost white. The other was the fleece of a yearling ewe. This was clean, slightly harsh and almost white, but was slightly coarser than that of the ram.

These fleeces were considered by a firm of London brokers as an excellent class of carpet wool and likely to meet always with a ready sale in the London market (see BULLETIN OF THE IMPERIAL INSTITUTE, vol. x. 1912, p. 537). A similar opinion was expressed immediately before the war (July 1914) by a London firm to whom two bales of Cyprus wool had been sent, of which a part had been purchased in the bazaar and washed and trimmed by the Department and part came from the Athalassa (Government) flock. It was considered as " an ideal wool for carpet making or for blankets, but deficient in lustre for braids."

The actual yield per sheep, viz. 3 to 3½ lb., compares unfavourably with that of Lincolns, which they most closely resemble. This is due partly to breed, but largely also to the conditions under which the sheep are kept (see p. 318).

Hemp

The cultivation of hemp (*Cannabis sativa*) is practically confined to the southern part of the Paphos district, and there only in places where the water-supply is ample. The plant is grown only for fibre, which is exclusively used for rope-making, which is carried out by hand by the villagers round about Ktima. It would be of advantage to have a rope-making machine at work at a spot centrally situated in the area of production. A simple hand-worked machine is now being experimentally used and will, it is believed, turn out a better class of rope.

The plant grows well on fertile and irrigated lands. Farmyard manure, and specially sheep manure, are generally applied, and chemical fertilisers are now also coming into use.

Harvesting takes place when the plants begin to turn pale. The plants are uprooted, not cut, and are made up into sheaves tied together at the butt end only. The bundles are not more than 2½ spans round, and of equal size. When first uprooted the sheaves are placed flat on the field in rows to dry and in such zig-zag fashion that the top end of one sheaf is always made to rest on the butt end of another, and thus does not come into contact with the ground : this ensures the circulation of air and hastens the drying process. The sheaves are taken later to the threshing-floors, where they are stood upright until they are dry. The seed is separated by beating. The sheaves are exposed to the sun until the leaves are shed, and when the stems are entirely dry the bundles are tied up at both ends and are taken to the retting-place, which is usually the common stone tank or cistern of the country. There they are steeped in water for six to nine days. The bundles are generally covered by about one foot of water. On the sixth day the fibre is tested. If it separates easily the bundles are removed, if not they remain for another two

or three days. This requires much care and experience, as the quality depends largely upon effective retting. Then they are taken out of the water and sun-dried, being piled up into pointed shooks, left hollow in the centre.

The fibre is separated by means of a wooden implement locally called "melidjia." This consists of a wooden trough placed on two legs which are fixed in the ground. A wedge-shaped piece of wood which is hinged to the trough at one end is used as the beater. The hemp stalks, after the butts are cut off, are placed in the trough and the beater worked up and down so as to split the stalks and lay bare the fibre.

The average production of fibre per scala is 60 to 80 okes, but where conditions are all favourable it may reach 160 to 200 okes and the seed yield may be anything from 80 to 200 okes per scala.

Silk

The silkworm (*Bombyx mori*) finds in Cyprus a climate exceptionally favourable to its development, and Cyprus silks have been famous for their quality throughout the middle ages and as far back as the sixth century A.D., when Greek monks first introduced silkworms from China.

In the fateful year 1845, when the disease pebrine nearly destroyed the silk industry of Europe, the anxious search for healthy silkworm eggs that then ensued led Arabs from Syria to visit Cyprus and buy large quantities of silk cocoons from which they raised and exported the eggs. At that time, therefore, it is evident that Cypriot moths were well thought of. Pebrine soon reached Cyprus and almost brought the Island breed to an end. Thanks, however, to the Pasteur system, whereby pebrine and other silkworm diseases have been brought under complete control, the industry both here and elsewhere was not only saved but has been considerably developed.

Writing in 1896 Mr. P. Gennadius, late Director of Agriculture, Cyprus, stated that the local production of silkworm eggs was so small that it could not be taken into consideration, and from the figures then given the total average annual production at that time is estimated to

have been 35,000 okes of dry cocoons. This represented an average yield of only 3½ okes of dry cocoons, equal to 15½ kilograms of fresh cocoons, per ounce of silkworm eggs. This compared very unfavourably with the average annual production of fresh cocoons in France and Italy at that time, which was 35 kilograms and 30 kilograms respectively per ounce of silkworm eggs. Moreover, this ratio had been, up to that period, on a descending scale.

In a report published in 1897 Mr. Gennadius attributed this unsatisfactory state of things to the following causes :

1. The importation of cheap silkworm eggs of inferior quality ; the average price paid by merchants was 2 to 2½ francs per ounce, while the price in France ranged from 9 to 12 francs.

2. The action of merchants who imported larger quantities of eggs than they could properly dispose of.

3. The ignorance and folly of rearers who undertook to rear far more worms than they could properly "educate," having regard to space, leaves and labour.

In 1908 the Department of Agriculture set to work, with some success, to improve the methods of rearing up to that time in vogue, and during the six years ending 1913 (inclusive) the average annual quantity of eggs hatched out was 12,319 oz., the average annual export of "dry" cocoons was 45,551 okes, and the average annual estimated local consumption 4,449 okes, making a total annual production of 50,000 okes, as against 35,000 okes in 1896. The former total represents an average yield of about 4 okes of "dry" cocoons, equal to about 18 kilograms of fresh cocoons per ounce of seed, and marks a slight improvement upon the ratio of eighteen years previously.

Since 1914 this branch of work has received a larger share of attention from the Department. Five sericultural stations have been established, regulations have been issued, inspections by qualified persons have been systematically made, practical advice has been given to rearers in the matter of cleanliness, disinfection and so forth, the granting of licences to egg-raisers has been put on a better footing and the whole industry has been brought more under observation and control.

Numerous suggestions have been made from time to

time for insuring that only a good quality of egg shall be imported. As an effective—perhaps the most effective—means to this end, the Department of Agriculture has set itself to improve the production of local eggs and thus indirectly discourage their importation : holders of licences to raise eggs are required to pass periodical examinations ; several have in consequence had their licences cancelled, new licensees have been added, and many unlicensed persons have been prosecuted and convicted for illegally raising eggs.

The common method of hatching practised by villagers, by placing the eggs tied in cloth with a little cotton-wool in their beds or by carrying them on their persons, still prevails, but it is gradually yielding to a better system of incubation. The Department has designed a simple, inexpensive hatching-box, and these are now being used with good results.

Until about three years ago probably 25 per cent. of the local rearers were producing their own seed without any microscopical examination at all. Bad feeding, bad ventilation, ill-adapted premises were general. As a consequence pebrine and flacherie played such havoc that many people were beginning to abandon silkworm rearing and uproot their mulberry trees. The expansion and increased resources of the Agricultural Department happily came just in time to check this backward move.

Silk reeling is unfortunately done in the most primitive manner with wooden appliances and hot water by village hand labour. The locally reeled silk is used only for Island consumption and the great bulk of cocoons is exported in the raw state, mostly to Lyons and Milan. The burden of freight on this bulky cargo is naturally a heavy handicap and the local silkworm rearers have consequently to be content with very low and inadequate prices for their cocoons. During the reeling process 20 to 25 per cent. of the silk is lost, and a further loss is incurred during weaving owing to the numerous knots having to be cut away and the silk threads rejoined.

A considerable loss is said to take place in selling cocoons in the European markets. The cocoons on arrival at Marseilles are subjected to official tests and sold according

to the reports made by the official testers. It is of advantage to the buyers that the report should be made as unfavourable as possible as the price is lowered proportionately, and it is felt that the cocoons exported are thus placed too much at the mercy of the testing officials.

These Cyprus cocoons are reeled in France and Italy and the silk is largely sold to England. It would be to the mutual benefit of England and Cyprus if a direct demand for Cyprus reeled silk could be created and modern reeling plant introduced into the Island. A large sum of money, now annually paid for freight, would thus be saved to the Cypriot producers, which would stimulate the local industry and tend to increase greatly the annual production and improve the local weaving of silk stuffs, an industry which has already gained considerable fame and at which the Cypriot women are adepts.

As the following table shows, the amount of raw silk exported is a negligible quantity, but a fairly large quantity is locally reeled and is used in making the silk stuffs which are so much sought after in the local bazaars :

Export of cocoons.			Export of cocoons waste.		Export of raw silk.	
Year.	*Okes.*	*Country.*	*Okes.*	*Country.*	*Okes.*	*Country.*
1909	41,013	France	2,120	France	6	Turkey
1910	44,550	,,	1,105	,,	259	,,
					157	Egypt
1911	57,422	,,	2,704	,,	246	Turkey
					70	Egypt
1912	43,196	,,	2,571	,,	90	Turkey
			70	Turkey	3	Greece
1913	48,884	,,	2,502	France	118	Turkey

Efforts have been made by the Agricultural Department to improve the Cypriot race of silkworms. Two races of white colour, the Japanese and the Baghdad, have been separately crossed with the yellow race of Baghdad. These crossings began in 1912–13 and have been continued up to the present. The objects aimed at are to establish a new Cypriot race (*a*) giving good cocoons of a fine structure and larger in size than the French variety and yielding a maximum quantity of silk ; (*b*) producing cocoons of a uniform colour and in demand in the European market and (*c*) with these characteristics constant.

The results obtained so far are promising, but uniformity of colour has not yet been attained, though it is hoped that, by careful selection, this will become more fixed every year. It may here be mentioned that the famous French cream-coloured race took seventy-five years to become fully established owing to the widespread damage caused by pebrine and, to a lesser extent, by flacherie.

It has been observed that silkworm eggs locally produced by qualified licensees are decidedly more immune to disease and less affected by adverse atmospheric conditions than imported seed.

The local conditions of sericulture in Cyprus have undergone a change of late years. Formerly Nicosia and Famagusta were the districts where this industry was chiefly carried on; but latterly whole mulberry groves have been uprooted and replaced by fruit trees which are considered to be more profitable. This was the inevitable result of the ignorant methods under which the silkworm-rearing industry was conducted and the use of bad seed permitted, whereby disease was spread and annual loss incurred. It is hoped that the industry is now again on the upward grade. One indication of this is that whereas a few years ago 1,000 to 1,800 cocoons went to an oke, now the figure may be put at 500 to 1,000. Again, the waste due to excess of floss is much less than formerly, and if only reeling by machinery can be introduced a very much better return will result to the cocoon producer.

In the Karpas and in and around Nicosia a bi-voltine race is reared. The results are poor, but the two rearings are made because in these localities there is an ample supply of leaves. From this race are produced small cocoons locally called "Confetti." They are only used for local silk manufacture.

An inferior silk called "Koukoularika" is made from the cocoons of the ordinary or univoltine race, both those which have been stoved and those which have been badly stained when the moths emerged.

These cocoons, which, during the process of boiling in lye, have been bleached, are turned inside-out and the excrement of the larva removed. The silk is then spun

by hand with the "atrachtos." These cocoons are mostly from laggard worms and of inferior quality.

The silk industry has suffered greatly from unscrupulous dealing on the part of the dealers in eggs. It is a common custom for these persons to sell imported seed at 2*s*. and even less per ounce, although the law requires all such seed to be accompanied by a Consular certificate and affidavit showing that the price paid was not less than 4*s*. per ounce, exclusive of freight, carriage or insurance. Secret discounts, presumably, render this practice possible. The dealer does not ask for payment in cash, but requires it in kind at the rate of 1 oke in every 4 okes of cocoons raised. If 28 okes of cocoons are obtained from 1 ounce of seed the dealer would get 7 okes, valued at say 2*s*. 6*d*. per oke = 17*s*. 6*d*. for each ounce of seed. The dealer mostly gives a cash advance of 10*s*. or £1 with the seed, stipulating that the crop is to be sold exclusively to him, the price being left open. The unfortunate producer is therefore in his toils.

The establishment of small Sericultural Societies would do much, both to encourage and cheapen the cost of growing mulberry trees and assist the industry. A few such societies have lately been formed.

Mulberry

This tree (*Morus alba*) is grown extensively for silkworm feeding and is mostly found in those parts of the Island in which the silk industry is centred, viz. in the Marathassa valley and in the Karpas, fairly generally in and around Nicosia, Kyrenia and in the southern parts of the Paphos district.

Little care is given to its cultivation. For the most part, in all the older plantations, the trees are set too close together. This is less noticeable in the newer plantations. Pruning, where given, is defective and so is the method of gathering the leaves.

The usual method is to cut off, every year, the shoots with the leaves on them, from about one foot above the main branches. Two reasons are given for this by villagers. (1) It is quicker and easier to cut off these shoots than to

pick off the leaves while still on the tree. The shoots are brought into the "magnanerie" and there placed upright in water and the leaves can then be removed more conveniently and at leisure. In this way the leaves remain fresh two days. (2) By cutting these shoots in the spring, *i.e.* during the silkworm-rearing season, which begins in early April, fresh shoots are formed which bear leaves in late summer and autumn. The latter afford very welcome green food for cattle and sheep. These leaves are stripped direct from the growing tree. The effect of this second gathering is prejudicial to the tree, which is thereby exhausted. The leaves produced the following spring are fleshy and watery and in the uncertain weather of spring are apt to induce flacherie.

Agaves and Aloes

Agave americana, A. rigida var. *sisalana, Furcræa gigantea, Aloe ciliata* and *A. frutescens* all grow well and, if properly cultivated and handled, might be worth more attention than they at present receive.

In 1913 a Cypriot from German East Africa who had been engaged in the production of Sisal hemp there was struck by the few excellent plants he found growing in Cyprus, and, had sufficient suitable land been then obtainable, with transport facilities, was desirous of undertaking cultivation on a commercial basis.

Samples of fibre prepared from the leaves of the above-mentioned plants were reported on by the Imperial Institute in 1912, but as the leaves had been retted, and not scraped or scutched, their value was depreciated, and this was estimated at from £14 to £18 per ton with best Mexican Sisal hemp at £25 per ton.

The outlay for fencing against wandering flocks of goats and for decorticating machinery and other expenses would deter the ordinary cultivator from planting, and this could only be profitably undertaken if ample capital were forthcoming.

Broom Corn

Until the end of last century all brooms of European type were imported. Seed of broom corn (*Sorghum*

vulgare), known locally as "tchihri" or "skoupa," was then introduced, and gradually the cultivation has extended and a good number of brooms of very fair quality are now locally made. The process of broom-making is very simple and the high price of the imported article during the war has led to a marked extension of the industry. The plant grows well, especially on irrigated land. The seed provides a good food for chickens and the stalks and leaves can be used as fodder. It is a profitable crop, especially when the cultivator makes and sells the brooms himself, and is principally grown in the Karpas and at Athienou.

Tobacco

In Turkish times tobacco was grown in several parts of the Island, though not to any large extent.

"For centuries it was produced in many districts of the Island, and particularly in the Karpas, near Kilani, Omodhos and Paphos, but from the time it became an article of monopoly its production was subjected to rigorous restrictions, and its cultivation has been entirely abandoned" (Reports, pt. ii. (1896), P. Gennadius).

The quantity grown before the occupation appears to have been very fluctuating and to have averaged about 56,000 lb. annually, and the Government revenue, according to British Consular reports, would not have been more than £300 to £400 per annum. The Régie was introduced in 1874, but owing to the hampering restrictions the industry had been pretty well crushed out by the time of British occupation in 1878. Meanwhile the revenue from tobacco, imported mainly from Volo and Salonica, increased greatly.

The monopoly ceased at the British occupation, but the regulations and imposts remained. Those responsible for controlling the industry, collecting dues, and checking illicit consumption had a troublesome task, while on the other hand the cultivator became averse to engaging in a cultivation which was hedged round with so many restrictions and formalities.

These exist at the present time and may here be quoted :

The grower has to notify the Customs authorities of his intention to sow, giving the locality and area. Before picking he must again notify the Customs, so that a Customs officer may be present at the picking and weigh the freshly picked leaves. After storing, but before delivering the tobacco to the factory, the Customs officer must again weigh the now dry leaves.

The excise duties leviable are: Tobacco leaf, 4½*cp.* per oke, payable on transfer of leaf from grower to wholesale dealer. Tobacco manufactured in Cyprus, whether made into cigarettes or otherwise, in addition to the import duty or transport duty, pays a banderolle duty of 3*s.* 6½*cp.* per oke.

These regulations are a relic of the Turkish times, as in those days the State received a definite due called "City Toll" by charging the tobacco cutters and tobacco sellers with a trade tax. They appear to have been administered with more laxity in Turkish than in post-occupation times, and it is said that the abandonment of tobacco cultivation was mainly due to the severity with which these rather vexatious and irritating regulations were enforced.

For many years the tobacco imported by local cigarette manufacturers came almost entirely from Macedonia. This tobacco was of very superior quality and cheap, and locally grown tobacco could not compete with it. Of late years the price of Macedonian tobacco has risen considerably and the manufacturers have therefore been induced to import Thessalian tobacco instead, which is not of so fine a flavour and approximates more closely to Cyprus produce. Cypriot smokers have thus had their palates prepared for the flavour of the locally grown tobacco.

About the year 1912, when Houry's Cyprus Tobacco Association, Ltd., was formed, a revival in the industry set in. This has since received considerable impetus from the war which, temporarily, has thrust Macedonian tobacco out of the market. The primary object of the Association was to manufacture tobacco and cigarettes from Cyprus-grown tobacco, although foreign tobacco could also be used. Tobacco then began to be regularly grown by the

Association at a Chiftlik near Limassol and elsewhere, and cigarettes made therefrom have had a fair local sale. The arrival of well-to-do refugees from Latakia and other parts of Syria, skilled in tobacco cultivation, led to great extension of this crop. A large part of the produce was at first converted into Latakia tobacco. Owing possibly to the lack of care and skill on the part of native labour, partly perhaps to the unsuitability of the herbs and brushwood used in the fuming, the market was not found sufficiently encouraging and the Latakia, for which at best there is a very restricted market, has almost ceased to be produced. Tobacco for cigarettes, however, continues to be grown on a fairly large scale, but in order that land suitable for corn and other foodstuffs should not be sacrificed to tobacco, the cultivation of the latter is permitted only by special licence. In 1916 and 1917 the industry fell almost entirely into the hands of the richer refugees, who were expert growers, and they contracted with the small farmers and peasants. A number of speculative growers, professional men, merchants, etc., were tempted by the prevailing high prices to embark in the industry, but the licensing system has tended to throw it more into the hands of the *bona-fide* farmers, who are allowed only to cultivate small areas which can be looked after mainly by their own families. In 1916 the total production was 89,065 okes, and the estimated yield for 1917 is 487,674 okes.

The Agricultural Department has for some five years carried out experimental growings in various districts, and samples of tobacco so grown have been submitted to the Imperial Institute (see BULLETIN OF THE IMPERIAL INSTITUTE, vol. xiii. 1915, pp. 547–550). The two best samples reported on were grown in the Nicosia plain. They were said to conform with the Turkish tobacco as regards size of leaf, but contained too much moisture for the English market. The tobacco was found to smoke rather hot and was only mildly aromatic, but it was believed that these defects would probably disappear with more experience in the curing. The samples referred to were incompletely cured, having been submitted quickly in order to roughly ascertain their quality. The report on the whole

was moderately encouraging, and it is hoped that later samples which have been better cured will be found superior.

The tobacco grown in Cyprus is mostly of the Samsoun, Trebizond, Kavalla and Hassan Keff varieties.

The normal importation of tobacco into Cyprus is about 180,000 okes, which produces an import duty of £4,500 a year, at the rate of 4½*cp*. per oke.

The average amount paid for banderolles on tobacco when issued from factories for consumption is about £30,000 a year, which at the rate of 3*s*. 6½*cp*. per oke equals a banderolle duty on 161,000 okes; the difference of about 20,000 okes would be cigarettes exported on which no banderolle duty is paid.

If, then, no tobacco were grown and none imported the Government would lose £35,000 revenue annually. It would appear to be immaterial from a revenue point of view whether tobacco were imported or grown in the Island, since the imposts are the same, viz. on imports 4½*cp*. per oke import duty and 3*s*. 6½*cp*. per oke banderolle duty; on locally grown tobacco 4½*cp*. per oke transport duty and 3*s*. 6½*cp*. per oke banderolle duty. There is, however, this difference, that the money leaves the Island when the tobacco is imported and remains and fructifies when it is locally grown.

Tobacco cultivation is in many ways well suited to this Island, as a great part of its cultivation as well as the gathering may be done by women and children. It need not therefore make any serious demand upon man labour, which is already insufficient, and much of the work can be performed by those who are unfit for heavy field work. It is a summer crop, which is greatly in its favour, the quality when grown "dry" being much finer than when irrigated. Its introduction broadens the basis of cultivation, provides a revenue from land that would otherwise lie fallow and is a useful element in any system of rotation. As it calls for careful preparation and thorough cultivation of the soil it has a great educative influence on a people prone to slovenly, primitive husbandry, and corn crops following tobacco have frequently given a larger, more uniform yield.

At the same time it is an open question whether the crop can be grown and the leaf cured by the Cypriot farmer to produce a tobacco which, under normal conditions, will successfully compete in quality and price with the Macedonian tobacco.

Tanning Materials and Dye-stuffs

Tanneries are fairly numerous and large quantities of skins are tanned and sold to native boot-makers. Before the war, goat- and sheep-skins and ox-hides were practically the only kinds handled, the two former being mainly used for the uppers of boots. The top-boots worn by villagers are nearly all made from goat-skin, locally called "totmaria." Since the war pig-skins and dog-skins have been also used. Camel-skins are often employed for making soles.

Pine bark and sumach are the native tanning substances chiefly used in the local tanneries. The pine is one of the commonest forest trees of the Island. Shinia leaves (*Pistacia Lentiscus*) are also used (see p. 352).

Sumach

The Sicilian, elm-leaved or tanner's sumach (*Rhus Coriaria*) is a shrub which grows wild throughout a large part of the Island, being principally found among the vineyards on the slopes of the southern range of hills. The leaves are largely used in the leather tanning industry, and a considerable export might have been established to the United Kingdom had it not been for dissatisfaction caused by the excessive presence of impurities, such as lentisc leaves and dust, which were usually found in the consignments sent.

One sample was sent by the Agricultural Department to the Imperial Institute in 1909. This was found to consist wholly of sumach and no lentisc or other leaves, and gave on examination the following results: Moisture, 10·1; ash, 9·8; tannin (by hide-power method), 26·9; extractive matter (non-tannin), 16·7 per cent. The report showed that the leaves produced a good leather, similar in texture and colour to that obtained with Sicilian sumach,

and was considered likely to fetch about the same price as a medium quality of Sicilian sumach, which contains from 25 to 30 per cent. of tannin (see BULLETIN OF THE IMPERIAL INSTITUTE, vol. x. 1912, p. 45).

Two further samples were sent in 1916. The first sample "consisted of a finely-ground yellowish-green powder, containing a quantity of sand, small stones and iron dust." The second sample consisted of a "coarsely-ground, yellowish-green powder, containing a quantity of pinkish unground twigs, sand and small stones, together with some iron dust."

The results of examination were as follows:

	No. 1. Per cent.	No. 2. Per cent.
Moisture	9·3	9·2
Insoluble matters	53·6	57·8
Extractive matters (non-tannin)	14·6	13·0
Tannin	22·5	20·0
Ash	8·5	12·3
Tintometer readings—Red	0·7	1·2
Yellow	2·1	2·5

Both samples were low in tannin, compared with the Sicilian percentage of 25 to 30.

Sample No. 1 was valued at £13, and No. 2 at £12, per ton, with Sicilian sumach at £15 per ton; the lower value being due to the lower tannin contents, owing to the presence of sand, dirt, etc. It may be assumed that if more care in preparing clean samples were taken, Cyprus sumach would greatly improve its market value.

Valonea

There are a few well-grown specimens of valonea oak (*Quercus Ægilops*) to be seen, but being a slow grower and as it takes many years to reach the stage when it yields a profit, it does not commend itself to the Cypriot tree planter. It prefers deep soil and requires artificial irrigation or a greater rainfall than we have in Cyprus.

It has been tried at Salamis and failed, and also at Machaera with the same result. It has been grown also on Troödos, but after six years' growth attained a height of only 1 foot.

Only an insignificant quantity of Valonea cups are locally produced. These come from the Paphos district and are said to be rather poor in tannin. The bulk comes from Anatolia. The pre-war price for the latter was 5*s.* per cantar of 44 okes, that for the locally grown was 20 paras per oke on the spot, transport charges bringing up the price to about 1 copper piastre per oke delivered.

Acacia Barks

Acacia pycnantha has been grown in Cyprus, but does not acclimatise well, and neither the soil nor climate seems favourable. *A. mollissima* also has not shown any very successful growth. *A. cyanophylla* and *A. longifolia,* on the other hand, thrive excellently. They are great drought-resisters and grow on almost any soil. They have been very extensively grown by the Forest Department in every district for fuel and along the coast upon sand dunes. They have not been utilised so far for the extraction of tanning, except experimentally. Samples of the barks of the two last-named species were found on examination at the Imperial Institute to be too poor in tannin to be worth exporting, but they should be quite suitable for use in Cyprus (see BULLETIN OF THE IMPERIAL INSTITUTE, vol. xi. 1913, pp. 412–414).

Madder

In former years, and within the period of the British occupation, the cultivation of madder (*Rubia tinctorum*) was fairly flourishing in Cyprus. The old madder grounds can still be distinguished, and are mostly to be seen near Morphou, Ayia Irini, Sotira, Ayios Serghios, Famagusta and Larnaca. These madder grounds were excavations made in order to expose the soil lying beneath 10 to 30 ft. of drift-sand; and they form, as it were, a series of tanks along the shore. The red dye obtained from the dried and ground madder roots constituted at one time one of the most valued of dye-stuffs, and was in special demand for military uniforms; but this has been entirely superseded by artificial coal-tar derivatives and, as Gennadius says: "The happy days of the cultivation of this plant are past, never to return."

It is propagated mostly by root cuttings. The leaf begins to dry at about the sixth month. There is no further growth above ground, but the roots continue to increase and shoot downwards till moisture affects them. "When they get too wet, they become black or rot. In Cyprus this rotting would often begin after about eighteen months, while in superior soils the roots would continue to improve during thirty-six months, and they would be known in the trade as eighteen months and thirty-six months roots. In Famagusta district they remain mostly eighteen months, while at Morphou they would continue fully thirty-six months, during the whole of which time the surface ground should be kept free of weeds."

After the root is lifted it is generally dried; if packed before quite dry, it ferments and deteriorates.

Two and a half tons of dried roots would be produced from an acre of good ground, and the madder grounds used to fetch a very high price.

Drugs and Other Products

Liquorice Root

The liquorice plant (*Glycyrrhiza glabra*, Linn.) grows mainly in the Famagusta and Kyrenia districts, and the roots are collected and exported from time to time. Two samples were reported upon in 1917 by the Imperial Institute (see Bulletin of the Imperial Institute, vol. xv. 1917, p. 312) and the following opinions of two London firms of brokers were elicited.

(*a*) One firm described the Lapithos (Kyrenia district) roots as medium to bold unpeeled roots of good flavour, fairly well cleaned and very well dried; and valued them at from 50*s*. to 55*s*. per cwt. ex wharf, London (February 1917). The firm described the Famagusta roots as thinner than the Lapithos sample and not so well freed from smooth valueless pieces, but mentioned that they had apparently been washed. They valued these roots at 50*s*. per cwt. ex wharf, London (February 1917). The firm added that both samples were exceptionally dry, and that it seemed doubtful if the material in the bulk would be as dry.

(*b*) A second firm considered the roots to be rather mixed, inferior quality, and worth at that time about 45*s*. per cwt. in London (February 1917).

Pyrethrum

Pyrethrum (*Chrysanthemum*) *cinerariæfolium* grows well from seed and is an attractive garden plant with pretty, marguerite-like flowers. These yield the pyrethrum of commerce so largely used as an insecticide, and which is said to form the chief ingredients in various flea powders. These flowers, when dried and ground to dust, are employed for this purpose by the natives. The original pyrethrum powder came from plants growing in Dalmatia.

The plant was introduced into the Cyprus Government Gardens some twenty years ago and has since spread more or less throughout the Island. It is perennial and drought-resistant, and will also stand several degrees of frost and seems indifferent to soil, provided it is not too damp. The seed is sown in September and the seedlings are transplanted in April or May, but it multiplies itself readily by suckers. The flowers, which are about three times the size of the Chamomile (*Matricaria Chamomilla*), which they closely resemble, are gathered as soon as they are fully open, and are then dried in a well-ventilated room. They are usually sold in bales of 50 to 100 kilogrammes. One donum may produce about 100 okes of flowers annually.

Squill

Bulbs of the local squill were submitted in 1917 to Kew and provisionally identified as *Urginea Scilla*. Like the asphodel, this root is found everywhere. If sliced and placed about the house they are said to drive away mice. It was intended by the Agricultural Department to make an attempt to find a market for these roots, in the hope that if they could obtain a small payment for them farmers might be induced to collect them off their lands, but the project had to be abandoned for the time owing to the war. There is a small demand for these roots, if sliced and dried, in Europe for medicinal purposes.

Squill bulbs from Cyprus were examined at the Imperial Institute in 1916 (see BULLETIN OF THE IMPERIAL INSTITUTE, vol. xv. 1917, p. 311). The samples, which were submitted to a firm of drug manufacturers, were objected to on account of their dark colour, and were valued at about 6*d.* per lb. as against a pre-war value of 3*d.* per lb.

According to the report by the Imperial Institute there are two varieties of *Urginea Scilla*, white and red, the scales of the former being yellowish-white and those of the latter having a reddish tint, and there are also many intermediate forms. Though the red and the white varieties have been stated to possess equal medicinal value, the white variety is preferred in England.

In making stone irrigation channels which are lined with a coating of lime and sand or earth, local masons sometimes rub over this lining with a sliced squill which has been dipped in oil. It is found that this tends to harden and glaze the lining and prevent it from cracking.

Colocynth or Bitter Apple

The colocynth (*Citrullus Colocynthis*), locally called "pikrankoura" or "petrankoura," grows wild in some parts of the plains. The round yellowish-green fruit, about the size of an orange or small melon, ripens in July to September and, after being gathered, is skinned and dried in the sun. It is used by druggists as a purgative. Until about ten years ago it was cultivated on a small scale and an annual export of about £400 in value took place, chiefly to England and Austria. It was then in demand, it is said, as an adulterant of quinine. The fruit is locally thought to be a remedy for rheumatism. For this purpose the fruits are picked and put in a saucepan and covered with olive oil. After cooking for six hours the pulp or ointment is rubbed into the affected part. The European demand having ceased, the plant is now only found in a wild state.

Asphodel

The asphodel (*Asphodelus ramosus*), locally known as "spourdellos" or "spourtoulla," is a troublesome and

abundant weed in many parts of the Island, up to an altitude of about 4,000 ft. The peasant farmer rarely attempts to remove it, though it occupies a large proportion of his land to the detriment of the crops. In the hills the villagers dry the bulbs and feed them to their sheep, cattle and donkeys. A paste is also made from the roots which is used by boot-makers to stick the leathers together. To make this paste the roots are dried in the oven and ground, and then mixed with ground vetches or maize and made into the gum or paste locally known as "tsirichi."

VI. MINOR AGRICULTURAL INDUSTRIES

Bee-keeping

Although Cyprus bees are world-famed, bee-keeping in the Island is still in its infancy.

The native hive is generally an earthenware cylinder or pipe about 2 ft. 6 in. long and 9 in. in diameter (see Plate VII, fig. 1). Hives are also made of a mixture of earth and chopped straw, similar to native mud-bricks. These hives are also cylindrical, about 18 in. long and 10 to 12 in. in diameter with a 3-in. thickness of wall. These are cooler in summer and warmer in winter, and produce stronger colonies than the earthenware ones.

Of late years the Agricultural Department has introduced modern hives with movable frames, and had it not been for the high cost of timber since the war, the number of these would have increased rapidly. The difficulty is to get the local carpenters to construct them properly and with finish. Practical hive construction is taught at the Agricultural School.

Cyprian bees are, par excellence, the yellow race of the world. They are of uniform colour, size and character, slightly smaller than the Italians and the blacks. They have great power of flight, are very prolific and vigorous and good honey-gatherers. They are by many considered vicious and ill-tempered. This is possibly due to the constant war they have to wage against hornets, which in this country are a real plague and frequently exterminate whole colonies and sometimes whole apiaries. Various

Plate VII.

Fig. 1.—Cypriot Earthenware Beehives

Fig. 2.—Shipping Fruit at Larnaca.

devices are employed for the protection of bees in or near the hives.

A good number of Cyprian queen bees have been imported into Europe and America, and are very highly regarded wherever they have been established. In the eighties Cyprian queens were sold in the United States of America at £2 each. This high price checked the importation and the crossing of Cyprians with Italians and blacks took place, the hybrid offspring being sold by dealers as Cyprians. These, however, did not possess the best characteristics of Cyprians, and for a time they brought about a reaction in favour of other breeds.

Cyprus possesses excellent honey-producing plants in the eucalyptus trees, orange groves, "throumbia" or wild thyme, and other aromatic plants.

In the neighbourhood of orange groves a competent bee-keeper can obtain an average of 50 lb. of honey per colony; although unfortunately the ordinary village bee-keeper gets little more than 6 to 10 lb.

Locally produced beeswax is of fine quality with delicious aroma and of a bright yellow colour, said to be superior to that imported from Asia Minor and Egypt.

The industry is susceptible of considerable development and, when brought under more complete control, should be capable of establishing a good export trade of honey and possibly of beeswax.

Basket-making

Basket-making is a considerable industry, as all fruit and much other produce is transported in baskets mostly designed for the backs of donkeys or mules. The export trade of fruit and vegetables creates a constant demand (see Plate VII, fig. 2). The bulk of these baskets are made of reeds (*Arundo*) which grow luxuriantly by the side of water channels or wherever moist soil is found. This material is not an ideal one for the purpose, as the baskets are easily crushed and lose shape, to the detriment of the contents. The reeds are therefore often stiffened by the introduction of an occasional breadth of some other material, *e.g.* shinia (*Pistacia Lentiscus*), tremithia or

myrtle. All these are much used in basket-making, though the latter is heavy. There is a native willow (*Salix alba*) and also the weeping willow (*S. babylonica*). These have not been used until recently when, by the efforts of the Agricultural Department, a number of these trees have been pollarded and the new shoots have been found quite satisfactory for the purpose.

Six years ago a number of osier cuttings were imported from England, but unfortunately they have not succeeded so far owing to a succession of dry years. The surviving plants were this autumn removed to a more suitable site, but after suffering from drought they have now been almost destroyed by heavy floods.

In order to encourage the manufacture of better baskets for the fruit trade between Cyprus and Egypt the Agricultural Department provides practical instruction in basket-making, and a qualified teacher pays occasional visits to basket-making villages and demonstrates the work and teaches improved patterns to the villagers and school boys.

Fruit and Vegetable Preserving

There is little doubt that the establishment of small factories for canning or bottling fruits and vegetables would be a profitable undertaking. Owing to the suddenness with which, in the heat of summer, the fruits ripen in Cyprus, and the consequent glut that often ensues, market prices fall to a point at which it does not pay to pick and handle. Transport difficulties also make it precarious, in the case of soft fruits, to attempt a sale outside the immediate place of production. Increased cultivation is thus discouraged.

In growing fruits or vegetables for canning or bottling a man is independent of market fluctuations, whereas at present both producers and consumers are in the hands of the local shopkeepers, who have the former entirely at their mercy.

The Egyptian fruit and vegetable trade is very well worth cultivating, but until better measures can be enforced in the matter of transport by sea as well as land,

shippers run the risk of heavy losses, which, no doubt, recoil upon the unlucky producers.

Specimens of most of the products referred to in these notes may be seen in the Cyprus Court in the Public Exhibition Galleries of the Imperial Institute.

GENERAL ARTICLES

PARA RUBBER SEED AS A SOURCE OF OIL AND FEEDING-CAKE

In 1903 the first results of the investigation conducted at the Imperial Institute as to the commercial value of Para rubber seed were published (this Bulletin, 1903, **1**, 156). These results showed that the kernels of the seeds contained a considerable amount of a drying oil, and that the residual meal or cake left after the extraction or expression of the oil was of high nutritive value. Numerous samples of seed, oil and cake have been examined at the Imperial Institute since 1903, the composition of the oil has been investigated, feeding trials have been made with the cake, and the oil has been submitted for trial to manufacturers in various industries. The information collected as a result of these investigations has been published from time to time in this Bulletin (*e.g.* 1904, **2**, 22 ; 1909, **7**, 95 ; 1911, **9**, 35, 286 ; 1912, **10**, 492 ; 1913, **11**, 156, 551, 682) and wide publicity has been given to the results in the various journals dealing with technology and economic products all over the world. Other investigators have since given attention to the subject.

Notwithstanding the fact that the kernels have been proved to contain a substantial amount of oil which should meet with a ready sale, and that the cake would be suitable as a feeding-stuff, neither Para rubber seed, kernels, nor oil have become articles of regular commerce, though small experimental consignments of the seed and kernels have been sold from time to time, and quite recently a small commercial consignment of oil has reached this country from Malaya.

It is the purpose of the present article to summarise the information available up to the present, and to discuss the possibility of establishing a regular trade in the seed and its products.

Characters and Value of Para Rubber Seed and its Products

I. Seed

The Para rubber tree commences to bear seed when about four years old; at first only small numbers of seeds are produced, but when about eight years old the trees come into full bearing. Each fruit contains as a rule three seeds. On ripening the fruit bursts, shedding the seeds, which fall to the ground. The principal crop of seed is obtained in the autumn, generally in September, October and November, and a small crop falls in the spring from about February to April.

The seed is light, of a roughly ovoid shape, flattened on one side, and consists of a hard but brittle woody shell of a greyish-brown colour mottled with dark brown, loosely enveloping a cream-coloured softish kernel. It consists on the average of about 50 per cent., by weight, of shell and 50 per cent. of kernel. In two samples of seed examined at the Imperial Institute the percentage of kernel was 44 and 42 respectively, whilst Spring and Day (*F.M.S. Agric. Bull.*, 1918, **6**, 232) record 63 per cent. of kernel in seed examined in the Federated Malay States.

The amount of oil in the kernels examined in the Imperial Institute has also varied slightly. Samples from the Federated Malay States examined in 1903 and in 1908 contained 42·3 and 48·8 per cent. of oil respectively, and kernels taken from a trial consignment sent to the United Kingdom from Colombo in 1909 contained 45 per cent. A consignment of seed sent from the Federated Malay States for manufacturing trials in 1917 yielded 20 to 22 per cent. of oil from the undecorticated seed. On the average it may be taken that air-dried kernels in good condition will contain 45 per cent. of oil, whilst they may contain as much as 50 per cent.

II. Oil

Para rubber seed oil, when freshly prepared from kernels in good condition, is of a yellow colour, clear and free from appreciable deposit of solid acids or "stearin." The constants of various samples examined at the Imperial Institute are given in the following table; those of linseed oil are added for comparison:

	Para rubber seed oil.							Linseed oil.
	1	2	3	4	5	6	7	
Specific gravity at 15°/15°C.	0·930	0·932	0·925	0·924	0·925	0·927	0·924	0·931-0·937
Acid value	10·7	19·0	16·8	29·9	40·9	49·0	56·4	—
Saponification value	191·8	193·0	192·1	185·6	188·5	192·9	193·4	189–195
Iodine value, *per cent.*	128·3	121·2	131·4	133·3	143·3	136·5	135·0	175–200

1. *Extracted in United Kingdom from kernels of undecorticated seeds from Malaya* (1903).
2. *Extracted in United Kingdom from whole seeds from Malaya* (1903).
3. *Prepared by expression from kernels in Malaya* (1908).
4. *Extracted in United Kingdom from kernels of undecorticated seeds from Malaya* (1908).
5. *From a consignment of Ceylon kernels extracted in the United Kingdom* (1909).
6. *From a consignment of Malaya seeds extracted whole in the United Kingdom* (1917).
7. *Part of a small commercial consignment of oil shipped from Malaya in* 1919.

It will be seen that the results of examination of the different samples are fairly uniform and show that Para rubber seed oil is a drying oil similar to linseed oil; the iodine value, however, is lower than in the latter oil.

The kernels contain a rather active fat-splitting enzyme, which causes the production of free acids, especially when the kernels are damaged, *e.g.* by being broken during shelling, or when they are not sufficiently dried before shipment. The high acid values of samples four and six, for example, appear to be due to the kernels having deteriorated before extraction. The seed can, however, be stored in gunny bags for periods up to six months, even in Malaya, without deterioration, if properly dried (see page 556).

An investigation of the constituents of the oil has been made by Messrs. Pickles and Hayworth in the laboratories of the Imperial Institute, and the results have been communicated to the Society of Public Analysts (see *Analyst*, 1911, **36**, 491). The oil used in this investigation was

extracted in this country from the kernels of undecorticated seeds (sample No. 4 in above table). The composition of the mixed fatty acids was found to be as follows: Saturated (solid) acids 14 per cent., consisting of stearic acid (m.p. 69°C.) and an acid or mixture of acids (m.p. 56·5° C.); unsaturated (liquid) acids 86 per cent., consisting of oleic acid 32·6 per cent., linoleic acid 50·9 per cent. and linolenic acid 2·5 per cent.

Technical Trials of the Oil

The earlier investigations made at the Imperial Institute indicated that Para rubber seed oil might be utilised in place of linseed oil for various industrial purposes. In order to ascertain its precise value in this direction samples were distributed in 1911 to a number of firms for technical trial, the results of which are summarised below:

Paint and Varnish Manufacture.—Samples of the oil were furnished to three firms for trial in the manufacture of paints and varnishes. One firm stated that the oil proved very satisfactory for their purposes, being about equal to linseed oil. They added, however, that their experiments were not carried on long enough to determine whether paint made with Para rubber seed oil lasts as long as that made with linseed oil, but they would not hesitate to adopt it in part of their manufactures, providing it was obtainable at an acceptable price. They stated that they would be prepared to pay 25*s*. to 30*s*. per cwt. for the oil if it were obtainable in considerable quantity (July 1912).

A second firm stated that the drying power of the oil was 30–40 per cent. less than that of linseed oil. They found that it dried with a "flatter" surface and considered that it would not show as good results in paint as linseed oil.

In the third case the oil was found to dry more slowly than linseed oil with the usual "driers" and to be more readily saponifiable than the latter oil.

Linoleum Manufacture.—Four separate trials were made with the oil for this purpose.

One firm stated that Para rubber seed oil is not completely satisfactory as a substitute for linseed oil in the manufacture of linoleum, but that more extensive trials are necessary before a definite conclusion could be reached.

In a second case the results were stated to be unsatisfactory. Some difficulty was experienced in drying the oil, and two manufacturers, who were supplied with samples of the oil by the firm conducting this trial, considered that it would be of very little value for linoleum manufacture.

Another firm stated that the iodine value of the oil is much too low to enable it to be used as a substitute for linseed oil for the manufacture of linoleum, but they expressed the opinion that it might take the place of soy bean oil for making paint oils, but this would depend on its price.

The fourth firm also considered it to be unsuitable for linoleum manufacture.

Soft Soap Manufacture.—A firm of oil seed crushers stated that the oil would be very suitable for the manufacture of soft soap, and for this purpose would be about equal in value to linseed oil or cotton seed oil.

Manufacture of Rubber Substitutes.—It is possible that the oil may also be suitable for the manufacture of rubber substitutes.

It is obvious that though Para rubber seed oil is a drying oil it dries less quickly than linseed oil, and is therefore inferior to this oil for those industrial uses to which linseed oil is particularly suited. When linseed oil is high in price, however, it has to be replaced by oils that are intrinsically inferior to it for these purposes, and in such cases Para rubber seed oil would be a valuable substitute. On the whole, the results of these trials clearly indicated that there would be no difficulty in finding a market for Para rubber seed oil, provided it can be put on the market at a suitable price and in large quantities. In this connection mention may also be made of the fact that the process of "hardening" liquid oils by hydrogenation (see this BULLETIN, 1913, **11**, 660) may open a new market to oils of the Para rubber seed type for use in the manufacture of edible fats.

It should be borne in mind that the above conclusions were drawn from enquiries made some years ago, and that, owing to the war, conditions have altered considerably; manufacturers are now far less conservative in their attitude towards new or little-known raw materials, and there

can be no doubt that Para rubber seed oil if produced in quantity would sell readily in the future (cf. p. 547).

In 1917 a consignment of nearly 26 tons of seeds was sent from the Federated Malay States to oil manufacturers for trial in this country. The seed was ground whole and submitted to extraction by means of solvent, the following yields being obtained:

	Per cent.
Oil	19·3
Foots (*i.e.* impure oily deposit from oil)	2·93
Meal	76·6
Loss	1·17

The seed used was of normal character judging from a small sample submitted to the Imperial Institute which consisted of husk 45 per cent. and kernel 55 per cent. by weight. The oil produced on a manufacturing scale was of a rather dark brown colour and deposited a small amount of solid at ordinary temperature. The results of examination of the oil are included in the table on page 545 (sample No. 6).

A firm of paint manufacturers who tested the oil from this consignment of seed considered that it would be unsuitable for paint grinding or for varnish making, and stated that it might be used to some extent as a substitute for linseed oil, but more probably for admixture with other oils. The value of the oil in their opinion would be about two-thirds that of linseed oil. The oil produced in this trial was, however, sold at £50 per ton with linseed oil at £60 per ton.

More recently a small consignment of oil prepared at a privately owned mill in Malaya was sent to this country. Some of this was sold at prices even more nearly approximating to that of linseed oil.

III. Cake and Meal

The cake or meal left after the removal of the oil from the kernels forms a valuable feeding-stuff for livestock. When the entire seeds are treated, however, the value of the residue is reduced, owing to the large amount of fibre present. The results of analyses of various samples of the cake and meal are shown in the following table; analyses of oil cakes in common use are included for comparison:

	Para rubber seed.					Linseed.		Cotton seed.	
	From kernels, decorticated cake.			From whole seeds, undecorticated cake or meal.		Cake, English made.	Meal.	Undecorticated cake, English.	Decorticated meal, Atlantic ports.
	Expressed. 1	— 2	Expressed. 3	Extracted. 4	Expressed. 5	Expressed.	Extracted.	Expressed.	Expressed.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	6·91	7·72	8·75	8·24	11·52	11·16	13·15	13·75	7·40
Crude proteins . . .	29·93	33·45	30·19	17·50	15·31	29·50	34·75	24·62	42·37
consisting of:									
True proteins . . .	27·03	30·21	24·85	—	—	—	—	—	—
Other nitrogenous substances	2·90	3·24	5·34	—	—	—	—	—	—
Fat	17·68	8·00	8·71	4·48	6·08	9·50	3·03	6·56	10·16
Carbohydrates, etc. (by difference)	35·97	40·20	41·74	32·29	31·97	35·54	34·67	29·28	25·86
Fibre	4·82	5·39	5·01	34·86	32·54	9·10	8·75	21·19	7·06
Ash	4·69	5·24	5·60	2·63	2·58	5·20	5·65	4·60	7·15
Nutrient ratio . . .	1 : 2·6	1 : 1·8	1 : 2·0	1 : 2·4	1 : 3·0	1 : 1·94	1 : 1·16	1 : 1·67	1 : 1·16
Food units	155	143	139	87	85	133	129	107	157

1. *Cake imported from Rangoon. Analysis made at Imperial Institute.*
2. *Sample No.* 1 *recalculated on the basis of* 8 *per cent. of fat.*
3. *Cake made from kernels imported from Ceylon. Analysis made at Imperial Institute.*
4. *Meal obtained in manufacturing trials* (*see p.* 548).
5. *Quoted by Messrs. W. Graham & Co. in "India Rubber Journal"* (1911, **42**, 1000).

It will be seen from the foregoing table that decorticated Para rubber seed cake is strikingly similar to linseed cake and meal in composition, and that what difference there is, is in favour of the former; it is somewhat inferior to decorticated cotton seed meal, but much superior to undecorticated cotton seed cake. The chief difference is in the quantity of "fibre," which is only about 5 per cent. in the case of decorticated Para rubber seed cake, against about 9 per cent. in linseed cake or meal, and about 7 and 21 per cent. respectively in decorticated and undecorticated cotton seed cake or meal. It is to be remembered, however, that the item "carbohydrates" is not a specific determination and probably includes different carbohydrates in different cases. Thus in the case of linseed there is much mucilage, which accounts to some extent for the hardness of linseed cake. Para rubber seed cake, on the contrary, is soft and inclined to crumble easily, so that it probably contains but little mucilage.

Para rubber seed kernels contain a cyanogenetic glucoside. There is a possibility therefore that the cake may yield minute quantities of prussic acid. This, however, is also true of linseed cake, perhaps the most popular feeding-stuff with farmers in this country, so that, as has been pointed out already in this BULLETIN (1905, **3**, 373; 1908, **6**, 210), the mere production of small quantities of prussic acid affords no ground for suggesting that cake from Para rubber seed kernels will be unsuitable for feeding cattle. Further, Auld has found (*Journ. Agric. Science*, 1912–13, **4**, 409) that the formation of prussic acid from cyanogenetic glucosides in linseed cake is inhibited by conditions existing in the digestive tract and by the presence of various substances existing naturally in the digestive tract (*e.g.* acids and alkalies) and also by the presence of other foodstuffs such as molasses and salt, and notably by the cellulose contained in such feeding-stuffs. The cake represented by analysis No. 3 in the foregoing table yielded approximately 0·02 per cent. of hydrocyanic acid, but, as will be shown later, it produced no ill effects on the animals fed with the cake (see page 554).

Experiments on the digestibility of decorticated Para rubber seed cake were made by Auld (*Journ. Agric. Science*,

1912–13, **4**, 429). Material supplied by the Imperial Institute was used in this investigation, the cake being fed to sheep and the excreta collected and examined in the usual way. The results obtained indicated that the cake was one of the most digestible concentrated foods available ; this is no doubt due partly to the small amount of fibre present.

In estimating the value of an oil cake the amount of phosphoric acid and potash present has to be taken into consideration, as the greater part of these constituents is returned to the land in the manure from animals fed on the cake. The ash of sample No. 1 contained 33·52 per cent. of phosphoric acid (P_2O_5) and 34·89 per cent. of potash (K_2O) equivalent to 1·57 and 1·65 per cent. respectively in the original cake. In this respect also Para rubber seed cake is about equal in value to linseed cake, which contains 2·00 per cent. of phosphoric acid and 1·40 per cent. of potash.

Feeding Trials with the Cake

Two series of feeding trials have been carried out at the South-Eastern Agricultural College, Wye, with Para rubber seed cake, supplied by the Imperial Institute.

Series I

These trials were carried out in 1911 with about 4 cwts. of cake imported from Rangoon. An analysis of the cake is given in the table on page 549 (sample No. 1). It should be pointed out that this consignment of Para rubber seed cake was not of normal composition, inasmuch as it contained nearly 18 per cent. of fat, which is at least twice as much as would be left in the cake under ordinary commercial conditions.

The report on the feeding trials conducted at Wye with this consignment of cake was as follows :

Cows.—A quantity of the cake was moistened and fed to cows. All except three, which were usually averse to new foods, ate it readily. The cake was dry and powdery,

and was moistened before feeding for this reason. It was found to absorb its own weight in water, and was more appetising in this state than when fed dry. Several cows refused it in the dry state, but ate it readily when moist.

Three cows received the cake daily for five days, getting 4 lb. each day. They all ate it readily, and no scouring or binding effects were noticed, nor did the milk or cream appear affected in any way.

Sheep.—The cake was fed in a dry state to sheep and was eaten fairly readily. Some sheep ate their full allowance when it was mixed with other foods, but apparently had less liking for it when fed alone. No exceptional effects were noted.

Series II

A more extended feeding trial with 1½ tons of Para rubber seed cake, made experimentally from kernels imported from Ceylon, was carried out at the South-Eastern Agricultural College during the latter part of 1912 and the beginning of 1913. A sample from this consignment was examined at the Imperial Institute and the results are included in the table on page 549 (sample No. 3).

This cake probably represents fairly closely the material which would be marketed if Para rubber seed kernels were worked industrially on a large scale.

Sheep.—A group of store tegs accustomed to trough feeding were used for the experiment. The smallest admixture of the rubber seed cake with the usual concentrated foods was, however, detected by the sheep, and the cake was left uneaten. Even when the total food supplied to the sheep was reduced below maintenance requirements, and this low ration was continued for a fortnight, the sheep refused to eat the rubber seed cake. Mixtures of the cake and various other concentrated foods were also tried without success. Older sheep similarly refused the food, and in fact all attempts at feeding sheep with this sample of Para rubber seed cake failed.

Young Cattle.—The cake was fed to a pair of two-year-old fattening heifers, which readily ate the food. The quantity of cake was increased gradually to 8 lb. per head per day, but this caused pronounced scouring, and even

5 lb. of Para rubber seed cake eaten daily with 56 lb. of mangolds produced a slightly laxative effect on these immature animals ; the latter quantity of cake should therefore not be exceeded, as a rule, for such cattle. Further experiments with another batch of two-year-old beasts confirmed this conclusion.

Two of the beasts were killed at the conclusion of the experiment; the butcher reported the carcases to be of first-class quality, and the beef of excellent flavour. One of these heifers had received 6 lb. of the cake per day for ten weeks.

Dairy Cows.—Six barren cows with an average milk yield of 1½ gallons per day were used for this test, and were fed with increasing amounts of the cake, until at the end of a week each animal was receiving 14 lb. of cake per day. The cake was the only concentrated food supplied to the animals, and the ration was continued for six days without any marked change in the animals' excreta. The ration being richer than that previously allowed, the yield of milk rose, but the percentage of fat in the milk was practically unchanged. Butter was made from the milk produced during the first three days, and again from that of the second three, and in each instance the texture, smell and flavour of the butter were considered to be unaffected by the change of concentrated food. The butter was of slightly paler colour than that obtained from the same cows on a concentrated food ration of bran, dried grains, oats and Egyptian cotton seed cake.

Para rubber seed cake can thus be safely fed to dairy cows without fear of tainting the milk or adversely influencing the butter. Even the large quantity of 14 lb. per head per day seems to be without noticeable effect when fed to mature cattle.

Full-grown Fattening Cattle.—The cows mentioned above were fattened while still in milk, the daily quantity of rubber seed cake being reduced from 14 lb. to 8 lb., and 4 lb. of other cake added. The cows remained in a very healthy condition, and maintained a high milk yield until they were intentionally dried off about a month before sale to the butcher. The increase in live weight over an average fattening period of nine weeks was 1·7 lb. per cow per day,

and the milk yield over the same period was 0·85 gallon per cow per day, the cows being in milk an average of six only of the nine weeks. Para rubber seed cake thus appears to be a valuable fattening food for cows, producing very satisfactory increases in weight in mature animals, and giving rise to no ill effect even when the feeding is continued for a considerable time.

The value of Para rubber seed cake as a food for cattle has been clearly established by these experiments. As the first sample of Para rubber seed cake was eaten fairly readily in a dry state by sheep (see p. 552) it would appear that the aversion of sheep to the second sample must have been due to some peculiarity which it possessed, or to some idiosyncrasy in the sheep used, and it will not be desirable to draw a definite conclusion as to the unsuitability of Para rubber seed cake as a food for sheep without further trials.

Collection and Preparation of Seed and Manufacture of Oil

I. Collection

As already mentioned, the fruits of the Para rubber tree burst and liberate the seeds, which consequently have to be collected from the ground. Various proposals have been made to facilitate collection, but so far no really practical method appears to have been devised. It has been suggested that platforms made of bamboo or palm leaves, and sloping towards the centre of the lines, might be placed between the trees at the time the seeds are being shed, but the cost of such structures would probably be too great, and there would be difficulty in safely storing in a wet climate the large quantities that would be needed. On plantations that are clean-weeded all that need be done would be to rake up the dead leaves and grass beneath the trees just before the seeds fall, as is done in the case of mowra flowers in India, so that the seeds could be collected in a fairly clean condition. Where cover crops or green manures are grown, however, the difficulties of collecting the seeds would be greater.

The question of the cost of collection is reserved for discussion in a later section (p. 558).

II. Preparation of the Seed

The seed should always be decorticated or shelled, whether the oil is prepared in rubber-growing countries or in this country. In the former case decortication is desirable, as the quality of the cake is better than if the whole seed is crushed (see page 548). Where it is intended to transport the material for any distance, decortication is essential owing to the bulky nature of the seed and the fact that the shells, which constitute about 50 per cent. by weight of the seed, are of little or no value.

For shelling the seeds the installation of machinery is desirable. Trials with Miller's nut-cracking machine (see this Bulletin, 1917, **15**, 73) at the Imperial Institute have shown that this can be used for the purpose; but it is necessary that trials on a comparatively large scale with the various machines available should be made before definite recommendations in favour of any one make are made. It is essential that the machine adopted should crack the shells without damaging the kernels, since the latter deteriorate somewhat rapidly when they are broken and exposed to air. This is of small importance when the kernels are to be utilised locally and at once for the expression of oil, but it becomes all-important if the kernels are to be exported.

It is not possible at present to recommend definitely any particular type of machine, but there is no reason to anticipate difficulty in devising or in adapting existing machinery for this purpose, nor should any insuperable difficulty occur in separating the kernels, after shelling, from the broken shell.

The shells are practically devoid of oil, and can be utilised as fuel for smoking rubber or as fuel in raising steam.

Kernels for export should be thoroughly dried before being packed in bags for shipment. This can be effected either by exposure to the sun or by artificial means. When these precautions are taken it is quite clear that the kernels can be shipped to Europe, and will arrive in sound condition. In 1909 a small experimental shipment was made to this country from Ceylon, and it behaved quite satisfac-

torily on expression and furnished oil of excellent quality. In 1911 a further small shipment of kernels was received at Liverpool, and a sample of these, kindly supplied to the Imperial Institute by the purchaser, was found to be in good condition, and to give a normal yield of oil of good quality.

Experiments made by Spring and Day in the Federated Malay States have shown that seed which has been properly air-dried can be stored in gunny bags for periods up to six months without suffering damage (*F.M.S. Agric. Bulletin*, 1918, **6**, 231). When stored in this way precautions would have to be taken to ensure ventilation, so as to prevent the growth of moulds, and also to protect the seed from attack by rats and weevils.

III. Manufacture of Oil

The oil may be removed from the kernels either by expression or by extraction with solvents in the usual way.

In the preparation of the oil trouble may arise from the presence of a fat-splitting enzyme in the kernels, as this is taken out with the water expressed along with the oil, and if this aqueous layer is left in contact with the oil, the oil will be rapidly converted into glycerine and fatty acids. Similar fat-splitting enzymes, however, occur in other oil seeds (*e.g.* in castor seed), and these as a rule occasion no difficulty in the industrial preparation of the oil; and it may be assumed that if due care be taken not to allow ground-up seed or kernels to stand about before expression or extraction of oil, and to separate the "foots" from the oil after manufacture, no trouble will arise with Para rubber seed from this cause.

Possibility of Exploitation of Para Rubber Seed

From the results of technical trials of the oil and of feeding trials made with the residual cake or meal recorded in the foregoing pages, it is clear that both these products should be readily saleable in the United Kingdom, on the continent of Europe, or in America. There is therefore no doubt that the kernels would be saleable in any of these countries, while oil or cake produced in rubber-growing

countries should find a market either on the spot or after exportation.

The question then arises as to whether it will pay the rubber grower to exploit the seed as a by-product of the rubber industry. This depends on a number of factors, the chief of which are the cost of collecting the seeds from the plantation and of their delivery either to oil mills in the rubber-growing districts, or in other countries, and the possibility of obtaining a sufficient quantity of seed.

In attempting to introduce a new or little-known oil seed it is essential that manufacturers should be assured of the possibility of regular and large supplies of seed; small or irregular supplies are of little or no value, as the products are almost certain to fetch low prices; while extra costs are incurred in collection and shipment of seed, and also in manufacture of oil and cake, owing to the necessity for modifying methods of working or even of modifying the actual plant used in manufacture.

Area under Hevea

That very large quantities of rubber seeds or kernels might be placed on the market by rubber planters, provided the price offered is sufficient to repay costs of collection, transport, etc., is evident when one considers the large area of rubber plantations in various countries.

The following figures (*Malay Tin and Rubber Journ.*, 1918, **7**, 264) show the area of rubber plantations in 1916 according to information published by the Rubber Growers' Association (the figures for which agree closely with an independent estimate of Messrs. Rickinson & Sons).

	Acres.
Malay Peninsula	1,033,069[1]
Burma	58,000
South India	44,500
Ceylon	240,000
British North Borneo	31,500
Dutch East Indies	529,712[2]
Cochin China	42,500
New Guinea	13,300
Total	1,992,581

[1] *Small holdings in Malaya are estimated at* 15 *per cent. of estate figures.*
[2] *Including* 18,800 *acres other than Hevea.*

Taking a recent estimate of plantations in Malaya, it is evident that the area under rubber has increased since 1916, but that some allowances must be made for areas not yet planted or bearing trees still in an early state of growth.

	Area at end of 1917. *Acres.*
Total area of estates in Malaya	1,908,993
Area under rubber alone	1,026,360
,, ,, ,, and catch crops	19,460
Area producing rubber	632,929
,, planted in 1917	93,950

It will be seen from the last estimate that only a part of the total area in Malaya was actually planted or had reached an age when seed would be produced; but without going into similar details for other countries, and allowing for the fact that some plantations are unfavourably located for transport of products such as rubber seed kernels, oil, or cake, which are bulky and of comparatively low value in relation to rubber itself, and that collection might be difficult on estates where cover crops are grown, or which are hilly, it should be quite safe to assume that at least 1,000,000 acres of rubber plantations are now producing seed.

Yield of Seed and Cost of Collection and Marketing

Unfortunately estimates of the amount of seed yielded per acre per year, and of costs of collection, are very variable; early estimates were largely based on the number of seeds per tree at a time when seed for planting was in strong demand in the early days of rubber planting, and when trees were more closely planted than is the rule at the present time; further, it is now almost impossible to distinguish estimates which are actually based on first-hand observations from those estimates based on figures quoted by others, while it must be remembered that yields of seed per year will vary with conditions of soil and seasonal variations of climate, etc.

Among the earliest attempts to estimate the yield of seed from rubber trees, mention may be made of the following by Carruthers, Director of Agriculture of the Federated Malay States (*Rept. for* 1908, p. 8). According

to his experiments, made on a few seeds only which are not stated to be air-dried, and may have been freshly gathered, 111 seeds weighed 1 lb. or 248,640 seeds to the ton; the seeds contained about 60 per cent. by weight of kernels, so that 414,400 seeds would require to be collected to produce 1 ton of kernels. At this rate with trees yielding 400 seeds each, and planted 15 ft. apart, *i.e.* 193[1] to the acre, 5·4 acres of plantation would be required for 1 ton of kernels, *i.e.* 1 acre would yield 3 cwts. 79 lb. of kernels. This author estimated the cost of placing the kernels on the market as follows:

	£	s.	d.
Freight at about 40*s.* per ton (say $18).	2	2	0
Collecting seed at 4 cts. per 1,000 ($18·64)	2	3	6
Decorticating per ton ($2·50)	0	5	10
Packing per ton ($15·00)	1	15	0
Total ($54·14)	6	6	4

Taking the value of the kernels at £11 per ton (that is, the price at which Para rubber seed kernels were valued in the United Kingdom in 1903), this would give a profit of £4 13*s.* 8*d.* per 5·4 acres or about 16*s.* per acre.

This estimate was considered far too low by Macmillan and Petch (*Journ. d'Agric. Trop.*, 1910, **10**, 284, and *Circulars and Agr. Journ., Roy. Bot. Gard., Ceylon*, 1908, **4**, 90), who pointed out that in Ceylon the cost of collecting 1,000 seeds was 4*d.*, and that Mr. Carruthers' estimate of the number of seeds required to produce 1 ton of kernels was based on the weight of seeds from untapped trees. It has been shown in Ceylon that seeds from tapped trees are smaller and lighter than those from untapped trees, and Macmillan and Petch estimated that from tapped trees at least 700,000 seeds would be needed to produce 1 ton of kernels. On the basis of their data, the cost of collecting sufficient seed to produce 1 ton of kernels would be £11 13*s.* 4*d.*, which was at that time a prohibitive price so far as the export of these kernels as an oil seed is concerned. It should be pointed out that Macmillan and Petch's criticism of Carruthers' estimate was mainly directed to the question of the quantity of seeds required

[1] Trees are not now planted so closely.

to produce 1 ton of kernels, whereas the principal difference between the two estimates was in the cost of collection, which appeared to be nearly four times as great in Ceylon as in the Federated Malay States. In this connection it may be mentioned that Ridley, at that time Director of the Singapore Botanical Gardens, suggested that the right of seed collection in plantations in the Straits Settlements might be leased to Chinese, who would be able to utilise for this purpose the labour of village children. Where this plan is feasible it would appear to afford a comparatively simple solution of the labour difficulty in Malaya.

In this connection most authorities appear to consider that it would be too expensive to employ coolie labour, but that where children are available it is desirable to employ them.

Morgan, of the Rubber Growers' Association, has also discussed the cost of collection, etc. (*Preparation of Plantation Rubber*, 1913, p. 262). From actual experiments on some thousands of seed this author states that the proportionate weight of shells to kernels is as 5 to 3 in freshly collected seed, and that further some 20 per cent. of the weight of the fresh kernel is due to moisture; he assumes from results of experiments that 180 *fresh* seeds are equivalent to 1 lb. and criticises previous estimates of 160 seeds as being too low; allowing for a loss in drying kernels of 20 per cent., he calculates that 806,400 seeds would be required to produce 1 ton of dry kernels, which at a cost of 5 cents per thousand would cost £4 14*s*. for collection alone. The cheapest cost of collection, obtained on a small scale only, known to this author was 1*d*. per 1,000 seeds, or say £3 16*s*. 8*d*. per ton of kernels, and he considers this estimate too low and states that 5 cents (1·4*d*.) is more likely, especially as allowance must be made for bad seed. Altogether, this author considered that a margin of profit of £2 to £2 15*s*. might be obtained if the kernels fetched about £10, which he remarks should be sufficient to offer inducements to managers of rubber estates who are economically inclined, especially if less favourable conditions of the rubber trade in the future render it necessary for estates to pay attention to by-products.

Among the earlier estimates mention might also be made of that of Wray (*Journ. F.M.S. Museums*, 1905, **1**, 66), who states that 500,000 seeds are required to produce a ton of air-dried kernels, and that each tree produces over 1,000 seeds (a figure which in the light of more recent observations appears to be far too high). Petch (*Journ. d'Agric. Trop.*, 1910, **10**, 284) states that in one experiment as many as 1,000,000 seeds were required to produce 1 ton of dried kernels, and that the superintendent of a well-known Ceylon estate, who had collected quantities of seed for distribution to planters, mentioned that only 100 seeds were obtainable from twelve-year-old tapped trees. The best seed production noted for old trees at Henaratgoda in Ceylon was 430 seeds, but it is stated that these trees, twenty to thirty years old, were too closely planted, and better results might be expected from trees of the same age but more widely spaced.

The question of the utilisation of Para rubber seeds was discussed in 1912 in an article in *Tropical Life* (1912, **8**, 72). Trees in full bearing were reported by some estates to yield about 8 tons of seed per 100 acres, or only about 179 lb. of seed per acre, which at 200 trees per acre (too high a figure for recent plantations, which are now more widely spaced or thinned out) is less than 1 lb. per tree; in spite of this low estimate it is calculated that the area recorded for Malaya alone in 1911, when in full bearing, could produce about 28,000 tons of seed, while Ceylon and other countries should furnish about 40,000 tons of seed, and supplies might possibly be obtained from wild and cultivated trees in Brazil.

The above estimate of 8 tons of seeds per 100 acres is similar to an early estimate kindly furnished to the Imperial Institute by a firm interested in this question, in which 1 ton of kernels was stated to be obtainable from 20 to 25 acres planted with 140 trees per acre.

The majority of the references to costs of collection and yields per acre or per tree appear to be based chiefly on small-scale experiments, and unfortunately no records can be found giving the actual costs of collection of seed on any considerable scale. The nearest approach to an estimate of cost of collection on a fair scale is that given by Spring

and Day (*F.M.S. Agric. Bulletin*, 1918, **6**, 232). In this case 6 tons of seed were collected and packed for the Department of Agriculture at a cost of about $100, *i.e.* £11 13*s.* 4*d.* This works out at £1 2*s.* 3*d.* per ton for seed, and, assuming that the seeds yield 63 per cent. by weight of kernels (see below), about £1 15*s.* 3*d.* for seed to produce 1 ton of kernels. The authors remark that the cost would vary with the crop of seed, and that it would not be profitable to collect seeds too frequently; once in two or three weeks during the fruiting season is recommended, as there should be a good fall of seed in such a period, and it would not deteriorate if left on the ground. Children paid at the rate of 18 cents a day can collect about 5,000 seeds, *i.e.* about 3·18 cents (say 0·9*d.*) per thousand. Experiments quoted by these authors show that the air-dried seeds contain 63 per cent. by weight of kernels, that there are 267,000 unshelled seeds to 1 ton and hence 427,000 seeds are required to produce 1 ton of air-dried kernels. On this basis and at the rate quoted above, 1 ton of seed would cost approximately $8·49 (say 19*s.* 9*d.*), and seed to produce 1 ton of kernels approximately $13·58 (say 31*s.* 8*d.*) for collection alone, and the authors consider that systematic collection of seed would be more costly. Unfortunately no data are given as to the area or number of trees actually required to produce the 6 tons of seed mentioned in the experiment above; nor do such data appear to have been published in relation to a small consignment of about 30 tons of seed which were sent to England for manufacturing trials and valuation (*loc. cit.* p. 243). The authors state, however (*loc. cit.* p. 231), that "an estimated yield of rubber seed received from four outside estates in this country [Federated Malay States] amounted to 652 tons, which works out at 330 lb. per acre per annum." They remark that "it is difficult to obtain an average weight of seed per acre, since the season as well as the many varying conditions of different estates has a considerable bearing on the crop," but if one assumes an average yield of 400 seeds per tree, 90 trees per acre, and 2,000 seeds to weigh 17 lb., one arrives at a figure—306 lb. per acre—agreeing fairly closely with the above figure. On the above basis from about 11½

to 12¼ acres would be required to produce 1 ton of kernels.

In an article by de Lange (*Nederl. Ind. Rubbertijdschrift*, 1917, **2**, 67) on rubber seed as a source of oil, it is stated that an early estimate showed 300 seeds per tree, of which about 100 were lost on the ground through rotting, while the cost of collection was 8 cents (2·24*d.*) per 1,000 seeds. A more recent experiment showed as many as 850 good seeds per tree, and the cost of collection and of bringing seed to the factory only 3 cents (0·84*d.*) per 1,000.

This author assumes 1,000 seeds to weigh 8 lb. (*i.e.* 280,000 seeds per ton, a figure corresponding well with that given by Spring and Day, cf. p. 562). With 200 trees per bouw (1·75 acre), equivalent to 114 trees per acre, a yield of 775 lb. of seed per acre would be obtained (this is more than double the figure given by Spring and Day).

This author then proceeds to calculate the cost of production of Para rubber seed oil as follows :

	fl.	£	s.	d.
Collection of 500,000 seeds at 3 cents. per 1,000	15·0	1	5	0
Wages (at 20 per cent. value of oil, viz. fl. 114)	22·80	1	18	0
Packing (in petroleum tins)	5·0	0	8	4
Freight charges (at 10 per cent. of value of oil)	11·40	0	19	0
Fuel and depreciation of machinery (at 5 per cent. of value of oil)	5·70	0	9	6
Cost to produce 380 litres—say 760 lb. of oil	59·90	4	19	10

The total cost for 760 lb. of oil is therefore equivalent to about £14 11*s.* 10*d.* per ton (2,240 lb.) ; the author values the oil at fl. 0·3 per litre or about £28 per ton. Assuming that the above costs of collection, working, etc., could be realised in practice, a very substantial profit is evident, especially as each ton of kernels will at the same time yield nearly ⅗ ton of cake.

In a comprehensive general article on Para rubber seed published by the Koloniaal-Instituut of Amsterdam (*Nederl. Ind. Rubbertijdschrift*, 1917, **1**, 260, 281, 298) the cost of collecting the seeds in Java and shipping one ton of kernels is summarised in the following way :

	fl.	£	s.	d.
Collection of 600,000 seeds	11·50	0	19	2
Sacks	11·50	0	19	2
Carriage to railway	11·50	0	19	2
Railway freight to Banjoewangi	2·00	0	3	2
Freight from Banjoewangi to Soerabaja	7·50	0	12	6
Lighterage	2·50	0	4	2
Coolie's wages	1·60	0	2	8
Normal rate of freight, Soerabaja to Southampton (Feb. 1915)	40·00	3	6	8
Total	88·10	7	6	10

The total cost, therefore, is about £7 10*s*., which, assuming a price of only £9 for kernels in England, shows a margin of £1 10*s*. This estimate appears to be, like others, somewhat incomplete, as, although some minor details are included, no mention is made of cost of decortication, though it is obvious that it is intended to export kernels and not whole seeds, whilst cost of supervision, insurance, depreciation of plant and brokerage also appears to be omitted. Further, the cost of collection of 600,000 seeds at 11·5 fl. or just under 2 cts. (0·4*d*.) per 1,000 seeds seems distinctly low compared with other estimates.

It is of interest to note that a factory was reported (*Trop. Agriculturist*, 1912, **39**, 251) to have been established in Ceylon for decorticating Para rubber seed, a price of £3 per ton being offered for seed; no details of further developments are available.

In addition to the preceding published figures taken from various sources, the Imperial Institute has in its possession figures courteously furnished by an important commercial undertaking, and obtained from a variety of sources in Southern India, Ceylon, Malaya and Sumatra in pre-war times. These estimates per ton are as follows:

Country.	
Federated Malay States	(1) £2 18*s*. to £3 10*s*.[1] (2) £9 4*s*. (3) £6 3*s*. (4) £6 12*s*. — for seed delivered at Port Swettenham
Southern India	£5 15*s*. for dried kernels f.o.b. Negapatam
Sumatra	£6 3*s*. for dried kernels f.o.b.
Ceylon	£3 4*s*. for seed delivered at factory; equivalent to about £7 per ton for kernels

[1] *This estimate covers out-of-pocket expenses only and does not include cost of supervision: estimates* 2, 3 *and* 4, *however, are regarded as being too high.*

It will be seen that there is a rather wide variation, especially when it appears that the Ceylon estimate includes any profit to the estates, while the other estimates do not appear to do so. At any rate it seemed unsafe to reckon on obtaining kernels for less than about £7 per ton at port of shipment.

From a careful consideration of even the more recent of the foregoing figures it will be seen that it is still difficult to make any certain estimate of the cost of placing Para rubber kernels on the European market. Discussion of the matter in the light of present conditions is extremely difficult, owing to the uncertainty of future charges for freight, both in rubber-growing countries and for ocean transport, of the cost of labour on rubber plantations and various other factors in this complicated problem.

It appears safe from a consideration of the available data to assume that about 500,000 seeds must be collected to furnish 1 ton of air-dried kernels. The costs of collection would therefore work out as follows in Malaya :

	£	s.	d.
At 3·18 cents per 1,000 seed about	1	11	8
At 5·0 ,, ,, ,, ,, ,,	2	18	4

The lower figure for cost per 1,000 seeds is that quoted by Spring and Day, who state that systematic collection would be more costly, though 6 tons of seed were collected *and packed* at the rate of £1 15*s*. 3*d*. per ton of kernels (see p. 562).

For the purpose of a conservative estimate it would seem advisable to take the higher figure. The cost of decortication is as yet uncertain, but decortication and air-drying of the kernels should not amount to more than 10*s*. or 15*s*. per ton of kernels. Packing would probably necessitate the use of 15 to 20 gunny bags, which would cost say 10*s*. (*i.e.* 8*s*. 9*d*. for 15 bags, assuming a price of 7*d*. each ; in 1912–13 gunny bags exported from India to Ceylon in large quantities worked out at about 5·4*d*. each, second-hand bags would be obtainable at about 2½*d*. each).

The cost per ton of kernels on the estate after decortication and packing would appear likely to work out at about £4 as follows:

	£	s.	d.
Cost of collection of 500,000 seeds at 5 cents per 1,000	2	18	4
Decortication and drying of kernels	0	12	6
Sacks (15 at 7*d*.)	0	8	9
	3	19	7

It might be noted that the price offered in Colombo in 1912 for *seed* was £3 4*s*. per ton (see p. 564).

The cost of transport from estate to rail will vary according to distance and local conditions, and rail carriage to port will naturally vary according to the distance and also according to the "class" under which the railway will carry Para rubber seed kernels; cheap river transport will in certain localities be available. Carriage by rail of oil seeds such as linseed or castor seed in Ceylon worked out under pre-war conditions at about 24*s*. per ton for 100 miles, and would probably be about the same in Malaya, though lower rates might be obtainable.

Ocean freights to the United Kingdom from the East are very high at the present time, and are likely to remain so for some time. Before the war the rates per ton of 50 cubic feet were approximately 33*s*. and 41*s*. for Penang or Singapore and Port Swettenham respectively. It is uncertain whether the 50 cubic feet allowance would cover 1 ton of Para rubber seed kernels in bags; from the light and bulky nature of the kernels it appears probable that it would not, and it would be safer to assume about 40*s*. for freight from Penang or Singapore and 45*s*. from Port Swettenham.

Under pre-war conditions the actual cost of exporting the kernels would probably amount to about £7 to £8 per ton as follows:

	£	s.	d.
Collection, decortication, packing	4	0	0
Carriage from estate to rail, railway freight of 100 miles to port and loading on steamship . . . . say	1	10	0
Ocean freight from Federated Malay States to United Kingdom at pre-war rates . . . . say	2	5	0
	7	15	0

When one considers that no allowance is made above for such inevitable items as depreciation of machinery and insurance, or for costs of sale in United Kingdom, it seems unlikely that Para rubber seed kernels could be sold ex-ship in the United Kingdom at less than £9 per ton, even if only a small margin of profit is allowed to the rubber estate; from the result of technical trials in pre-war times oil seed crushers in England were disinclined to pay more than about £10 per ton for kernels.

From the results of experiments and technical trials it is evident that Para rubber seed kernels in good condition should yield 40 to 45 per cent. of oil, according to quality and method of working, so that 1 ton of kernels may be taken to represent about 0·40 ton of oil, and 0·55 ton of oil cake (allowing 5 per cent. loss).

Para rubber seed oil and cake should be comparable in value with linseed oil and cake. For the purposes of a conservative estimate it would be safest to assume that their values would be only two-thirds of the values of linseed oil and cake respectively, though as mentioned previously (p. 548) a small quantity of Para rubber seed oil extracted in the United Kingdom from Malay seed sold in 1917 at £50 per ton, with linseed oil at £60, and a small commercial consignment of oil prepared in Malaya sold recently at prices almost equal to that of linseed oil.

Even under normal conditions the values of linseed oil and cake were subject to wide fluctuations. During the past fifteen years the lowest price quoted appears to have been in January 1905, viz. about £15 per ton in barrels. The average price for the years 1904–1905 was low, approximately £17 7*s.*; the average price then rose to about £42 for 1911, and fluctuated in the three following years as follows: 1912, £35; 1913, £24 17*s.*; 1914, £29. Prices rose much higher during the war, the maximum, under control, being £58 per ton, whilst the present price (March 1920) is £126 per ton.

The above prices are for the oil in barrels; making an allowance of about £1 10*s.* or £2 for this prior to the war, and of £4 since then, the average prices of the oil, naked, would work out at about £15 17*s.* in 1904–1905, about £40 in 1911, £25 during 1913–1915, about £54 in 1918,

and £122 in March 1920. The price of linseed cake also varied considerably, the approximate average prices being £7 6*s*. in 1904–1905, £8 16*s*. in 1911, £9 per ton during 1913–1915, £19 in 1918, and recently about £24 (March 1920). On the basis of these prices the products from 1 ton of Para rubber seed kernels would be worth as follows :

	1904–5.	1911.	1913–1915.	1918.	1920.
Linseed oil (naked), *per ton*	£15–17	£40	£25	£54	£122
Linseed cake, *per ton*	£7 6*s*.	£8–16	£9	£19	£24
Para rubber seed oil, 0·4 ton at two-thirds value of linseed oil . .	£4 5*s*.	£10 13*s*.	£6 13*s*.	£14 5*s*.	£32 4*s*.
Para rubber seed cake, 0·55 ton at two-thirds value of linseed cake .	£2 13*s*. 6*d*.	£3 4*s*. 6*d*.	£3 6*s*.	£6 18*s*.	£7 5*s*.
Total value of products from 1 ton of Para rubber seed .	£6 18*s*. 6*d*.	£13 17*s*. 6*d*.	£9 19*s*.	£21 3*s*.	£39 9*s*.

From the above figures it is evident that with the low prices ruling in 1904–1905 Para rubber seed kernels would have had to sell in the United Kingdom at a price too low to render collection and export profitable. With the higher prices ruling in 1911, the kernels might have sold at about £10–12 per ton, at which price a small profit might have been secured by the rubber estates ; in 1913–1915 it appears doubtful if any margin of profit would have existed. During the war there seems little doubt that the kernels might have been exported at a reasonable profit, even allowing for high freights. Under present conditions there can be no doubt that the exportation of kernels would be profitable, even if the oil is not worth more than two-thirds the value of linseed oil, and, as previously mentioned, it seems likely that Para rubber seed oil would command a price much nearer to that of linseed oil.

It seems probable that with a gradual reduction in the cost of ocean freight Para rubber seed kernels should become saleable in Europe at such a price as to render them available to oil manufacturers, and at the same time moderately profitable to the rubber estates ; though in view of the fact that collection of seed is troublesome and

somewhat costly, and that the yield of seed per acre is not large, it does not appear that Para rubber seeds can be regarded as likely to furnish large profits to owners of rubber estates. In view of the enormous demand for oils and feeding-stuffs, and of the obvious necessity for the exercise of economy on rubber estates, it is highly desirable that serious efforts should be made to organise the collection of Para rubber seed wherever it is likely to prove at all profitable and so prevent waste of material which is undoubtedly of appreciable value.

Under normal conditions it is evident that only a very intimate knowledge of all the factors of the problems would enable a decision to be made as to whether exploitation of rubber seed could be made sufficiently remunerative to encourage the collection of seed on rubber estates. Previous to the war numerous enquiries were made by firms of oil manufacturers and others into the possibility of collecting the seed and shipping the kernels. The results of practically all these enquiries were unfavourable; and the fact remains that though the possibilities of the seed kernels as a source of oil were pointed out in 1903, no regular trade in Para rubber seed kernels has been established up to the present time.

Production of Oil and Cake in Rubber-growing Countries v. *Shipment of Kernels to United Kingdom, etc.*

It has been suggested that Para rubber seed should be worked up on the spot in rubber-growing countries, and one estimate relating to this procedure has been quoted (p. 563); this could certainly be done, but there are objections to this plan. If the oil were produced in small quantities by means of small oil-crushing plant working on a rubber estate the cost of production would be high, and the quality of the products liable to variation; if a large central oil mill were established it would either have to work other oil seeds when Para rubber seed was not available (several months in the year) or arrange for the storage of large quantities of seed throughout the year. The latter plan would seem unlikely to prove remunerative. In any case the oil produced would have to be shipped in casks or steel drums, the original cost of which is high, whilst casks are

liable to cause loss and damage by leakage. One advantage of the production of oil in the country of origin of the seed is that the cake produced can be utilised locally either as a feeding-stuff or as a manure, so that impoverishment of soil does not take place. Para rubber seed cake should be readily saleable in Ceylon or Malaya as a manure, as castor cake containing about 4½ per cent. of nitrogen was worth in Colombo £4 13*s.* 4*d.* and in Penang £5 10*s.* per ton (pre-war, c.i.f.) and Para rubber seed cake would be worth more for use as a feeding-stuff.

In the event of manufacture of oil and cake on the spot, the whole seed or preferably the kernels might be either expressed or extracted by solvents; the initial cost of plant for either process is about the same, but great care in supervision of the extraction process is necessary to obviate danger of fire. Many of the recently equipped oil mills in the United Kingdom now employ extraction plant (made by British firms), and provided supervision is efficient there is no reason to discourage this process in countries employing native labour, though it seems possible that the storage and use of large quantities of volatile inflammable solvents in hot countries might be troublesome. On the whole it would appear to be the better plan, at any rate for the present, to decorticate the seed on the spot, and transport the dried kernels in sacks, either to a central oil mill in the East, or to the United Kingdom.

Summary

1. Para rubber seeds contain 20 per cent. or more of oil, the air-dried kernels about 45 per cent.

2. The oil should find a ready market at a price not lower than two-thirds that of linseed oil.

3. The residual (decorticated) cake is comparable in nutritive value and digestibility with linseed cake and decorticated cotton seed cake, and should be readily saleable as a feeding-stuff.

4. The possibility of exploitation depends very largely on the cost of collection of seed on plantations.

5. Authoritative and thoroughly reliable figures of yield of seed per acre per year and cost of collection are not yet available, but with the large area now under rubber

it is evident that large quantities of kernels could be obtained.

6. The oil and cake might be produced on the spot at a central oil mill or the dried kernels shipped to the United Kingdom.

CASSAVA AS A SOURCE OF INDUSTRIAL STARCH AND ALCOHOL

Among the economic plants of the Empire whose cultivation could be profitably extended, a prominent position should be assigned to cassava or manioc. Two forms of this plant are cultivated, "sweet" cassava (*Manihot palmata*) and "bitter" cassava (*M. utilissima*). The tuberous roots of both forms are rich in starch, and are used as a foodstuff in the countries where the plant is grown, for the preparation of tapioca and other food products, and as a source of starch for industrial purposes. An article dealing with the cultivation and utilisation of cassava was published in this Bulletin (1915, **13**, 581), and from the number and nature of the enquiries received at the Imperial Institute since then, it is clear that there is room for a considerably increased output of cassava products, for use as food and also for several purposes for which other farinaceous materials are at present employed in this country. In the present article the question of the industrial utilisation of cassava is dealt with more fully than was possible in the previous article, particularly as regards the use of the starch in the textile industries and the manufacture of industrial alcohol from the roots.

Trade in Cassava Products and other Farinaceous Materials in the United Kingdom

There is a large demand in the United Kingdom for cassava products, which is at present met chiefly by imports from foreign countries. The imports into this country of the chief of these products in the years 1913–1917 are shown, with the re-exports, in the following tables under the headings given in the *Annual Statement of the Trade of the United Kingdom*:

Trade in Cassava Powder and Tapioca in the United Kingdom, 1913–1918

	1913.	1914.	1915.	1916.	1917.	1918.
			Imports			
Total Quantity . . *cwts.*	290,183	299,097	485,439	368,755	396,869	125,536
Total Value . . £	250,524	235,817	460,053	504,768	1,048,821	396,582
	Cwts.	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
From:						
Straits Settlements and Dependencies, including Labuan	155,070	192,254	324,097	264,686	215,824	118,504
Other British Possessions .	430	—	3,510	710	23	445
Total British Possessions	155,500	192,254	327,607	265,396	215,847	118,949
Netherlands . . .	11,195	5,830	15	600	—	—
Java.	114,257	95,396	151,071	98,201	163,486	1,315
Other Foreign Countries .	9,231	5,617	6,746	4,158	17,536	5,272
Total Foreign Countries .	134,683	106,843	157,832	103,359	181,022	6,587
			Re-exports			
Total Quantity . . *cwts.*	21,233[1]	26,947[1]	102,339[2]	85,057[3]	14,027[4]	549
Total Value . . £	21,068	22,398	101,081	117,112	24,871	2,180

[1] *Chiefly to Denmark and the Netherlands.*
[2] *Chiefly to Netherlands, Denmark and United States.*
[3] *Chiefly to United States, France and Denmark.*
[4] *Chiefly to France and United States.*

Trade in Mandioca or Tapioca Flour in the United Kingdom, 1913–1918

	1913.	1914.	1915.	1916.	1917.	1918.
			Imports			
Total Quantity . . *cwts.*	643,312	566,528	382,834	289,341	306,062	463,635
Total Value . . £	248,155	251,883	199,031	227,977	386,516	1,199,368
	Cwts.	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
From:						
Straits Settlements and Dependencies, including Labuan	43,832	40,411	50,182	53,711	4,106	—
Other British Possessions .	—	—	3,160	—	—	9,039
Total British Possessions .	43,832	40,411	53,342	53,711	4,106	9,039
Netherlands . . .	227,663	96,538	5,760	700	—	—
Java	369,754	424,669	322,132	234,509	193,362	994
Brazil	70	—	—	125	90,814	448,602
Other Foreign Countries .	1,993	4,910	1,600	296	17,780	5,000
Total Foreign Countries .	599,480	526,117	329,492	235,630	301,956	454,596
			Re-exports			
Total Quantity . . *cwts.*	60,402[1]	186,095[2]	158,330[2]	18,335[3]	5,643	9
Total Value . . £	44,527	113,713	101,261	19,460	47,811	51

[1] *Chiefly to United States and Cuba.*
[2] *Chiefly to United States and Netherlands.*
[3] *Chiefly to United States.*

It will be seen from these tables that the assured market in the United Kingdom for cassava products is already large, and that it has been supplied during the six years in question, to the extent of 35 per cent. in the case of cassava powder and tapioca and 92 per cent. as regards tapioca flour, from foreign countries. The proportion derived from foreign sources is even larger than these figures indicate, as some of the produce shipped from the Straits Settlements comes originally from the Dutch East Indies.

To the tables given above, the following may be added, showing the imports of certain other farinaceous materials into the United Kingdom, since cassava starch and flour could probably be substituted, at least in part, for other forms of starch and flour used in a number of industrial processes, and more particularly for farina or potato flour. The imports of dextrin and glucose are included, since cassava can be used quite satisfactorily for the manufacture of these products.

Imports of Various Starches and Starch Products into the United Kingdom, 1913, 1917 and 1918

		1913.		1917.		1918.	
		Total.	From Foreign Countries.	Total.	From Foreign Countries.	Total.	From Foreign Countries.
			Per cent.		*Per cent.*		*Per cent.*
Farina or Potato Flour . .	*cwts.*	901,879	100 [1]	533,953	100 [2]	1,081,295	100 [3]
	£	556,021	—	1,040,319	—	3,827,143	—
Rice Starch .	*cwts.*	222,122	100 [4]	30,114	100 [5]	10,302	100 [6]
	£	214,255	—	58,145	—	40,419	—
Starch other than Rice Starch .	*cwts.*	907,635	99 [7]	942,167	98 [8]	180,150	95 [9]
	£	469,898	—	1,693,371	—	494,542	—
Rice Flour .	*cwts.*	145,211	99 [10]	17,175	94 [11]	3,430	100 [12]
	£	84,648	—	28,253	—	7,470	—
Sago and Sago Meal and Flour . .	*cwts.*	488,087 [13]	6	439,550 [13]	1	145,055 [13]	6
	£	234,211	—	763,142	—	498,038	—
Dextrin . .	*cwts.*	103,962	100 [14]	92,687	100 [15]	32,363	100 [16]
	£	70,870	—	181,278	—	117,959	—
Glucose .	*cwts.*	1,464,720	100 [17]	962,949	100 [18]	377,621	100 [18]
	£	739,254	—	—	—	1,255,237	—

[1] 49 *per cent. from Netherlands and* 32 *per cent. from Germany.*
[2] 92 *per cent. from Japan and* 5 *per cent. from Brazil.*
[3] 92 *per cent. from Japan and* 7 *per cent. from Brazil.*
[4] 40 *per cent. from Belgium,* 29 *per cent. from Netherlands and* 15 *per cent. from Germany.*
[5] 61 *per cent. from Japan.*
[6] 82 *per cent. from Japan.*
[7] 90 *per cent. from United States.*
[8] 92 *per cent. from United States.*
[9] 78 *per cent. from United States and* 12 *per cent. from Japan.*
[10] 86 *per cent. from Netherlands.*
[11] 92 *per cent. from United States.*
[12] *Countries of origin not specified.*
[13] *Mainly from the Straits Settlements.*
[14] 41 *per cent. from United States,* 34 *per cent. from Germany and* 24 *per cent. from Netherlands.*
[15] 91 *per cent. from United States.*
[16] 56 *per cent. from United States and* 44 *per cent. from Japan.*
[17] 98 *per cent from United States.*
[18] *All from United States.*

It will be seen from the above table that, with the exception of sago, which was shipped from the Straits Settlements, this country is dependent on foreign sources for all these materials. Before the war the chief countries supplying farina and rice flour were the Netherlands, Germany and Belgium, but in 1917 and 1918 almost the entire supplies came from Japan. The United States supplies most of the " starch other than rice starch " (consisting largely of maize starch), all the glucose and a large percentage of the dextrin, although in 1918 nearly half the dextrine came from Japan.

Cassava as a Source of Starch and Flour

Cassava starch has been tried as a sizing material for textiles in this country, but up to the present it has not been accepted by either the wool or the cotton trade as a satisfactory substitute for the farina, sago flour, wheaten flour or maize starch to which they are accustomed. In this connection colour is an important factor; it has recently been reported to the Imperial Institute that successive shipments have been found to vary considerably in colour, and under the circumstances consumers will not believe that they are receiving a product of uniform quality, whatever may be the evidence of chemical analysis and physical tests. It is possible that cassava starch might also be regarded with less disfavour for laundry purposes if this variability were eliminated.

As a sizing material cassava starch would probably be found less liable than cereal flour to induce mildew in cotton goods, on account of its much lower percentage of proteins. A sample of cassava starch prepared in Rhodesia and examined at the Imperial Institute was found to contain only 0·1 per cent. of proteins (see this Bulletin, 1917, **15**, 181; cf. also 1915, **13**, 598, 603). Wheat flour generally contains from 8 to 14 per cent. of proteins.

It is possible also that cassava starch would not produce the coarseness that is sometimes found in cotton goods stiffened with farina, which is supposed to be due to the large size of the starch grains in the potato. The granules of cassava starch, which in shape somewhat resemble

that of a kettle-drum, average about 0·012 mm. in cross section; they approximate in size the granules of maize starch, but are more regular in outline. Potato starch grains, which are somewhat oval in shape, vary in length from 0·05 to 0·14 mm., the breadth being never less than about half the length. Cassava is sometimes preferred to other forms of starch for sizing coloured goods, as it gives a clear "mixing" which does not destroy the brightness of the colours.

Another purpose for which cassava flour and starch can be used instead of farina is in the production of adhesives, which is an industry of some importance in this country. Cassava is also used as a source of glucose, of which it yields about 30 per cent., calculated on the weight of the fresh roots, and it should form a satisfactory material for the production of dextrin and "British gum" as well as of the dextrin "syrups" used in confectionery.

The flour could also be employed, at least in the countries where the plant is grown, as a bread-making material. Comparative information regarding the use of a number of farinaceous materials, including cassava, in conjunction with wheat flour for the production of bread, is given in *Bulletin No.* 701 (1918) *United States Department of Agriculture, "The Chemical Analysis of Wheat-Flour Substitutes and of the Breads made therefrom."* This publication gives photographs of loaves made from wheat in association with cassava and other farinaceous products. The bread made from wheat and cassava is described as having a remarkably fine texture and general appearance.

For particulars regarding the methods of manufacturing starch and other products from cassava reference may be made to the previous article in this BULLETIN (1915, **13**, 600).

The Imperial Institute examined and reported on a number of samples of tapioca flour and cassava starch from British Possessions before the war, and these were valued at prices ranging from £12 to £15 per ton, according to quality, and especially colour, the best prices being paid for the whitest starch (see this BULLETIN, 1912, **10**, 562).

The pre-war price in London of Dutch farina, which constituted the greater part of the imports, was from about £9 to £13 per ton according to quality. German

farina of ordinary qualities was quoted round about £12, while the best German farina realised as much as £16 per ton. Latterly Japanese farina has been coming on to the market in increasing quantities; early in the present year it was quoted in London at prices from 45*s*. to 60*s*. per cwt.

Early in 1919 cassava starch was quoted in London at prices from about 45*s*. to 50*s*. per cwt.

Alcohol from Cassava

The shortage of petrol brought about by the war has had the effect of stimulating attempts in several countries to produce alcohol from a variety of saccharine and starchy vegetable materials, for use in internal-combustion engines, both for purposes of transport and for agricultural machinery.

Reference has already been made in this Bulletin (1915, **13**, 604) to the use of cassava for this purpose. As a source of alcohol, one ton of cassava roots would in practice probably yield from 30 to 35 gallons of 95 per cent. spirit; one ton of potatoes yields about 20 to 25 gallons, and one ton of cereal grain about 40 to 60 gallons of 95 per cent. spirit.

As it appears very probable, from the experience gained during the war, that alcohol will remain a competitor with petrol as a source of mechanical energy, the following notes on the use of alcohol in internal-combustion engines will be of interest.

In consequence of the fact that alcohol is less volatile than petrol it has generally been found necessary to add to the alcohol a certain proportion of more volatile material in order to enable it to be used in engines constructed to work with petrol. Thus in Natal a mixture containing 60 per cent. of alcohol and 39 per cent. of ether, with small quantities of arsenious acid and ammonia gas, has been patented for use as a motor fuel under the name "Natalite." One advantage of using ether for this purpose is that it is itself easily manufactured from alcohol.

A mixture of 20 gallons of 95 per cent. alcohol with 5 gallons of benzol to which 8 ozs. of naphthalene have been added is stated to work quite satisfactorily in petrol engines, with no alteration except to the carburettor.

Denatured alcohol can, however, quite well be used by itself in internal-combustion engines of suitable construction. The correct construction of an engine intended to burn alcohol differs in certain details from that of one adapted to run on petrol, but the differences are not great and the necessary alterations can be made without much difficulty to an engine constructed for petrol. In employing denatured alcohol alone, without the addition of a more volatile material, it is necessary to use some other means, such as warming the carburettor with a spirit lamp or otherwise, to overcome the difficulty in starting "from cold." This is not an insuperable objection with stationary engines, but would be more serious in the case of automobiles, and for the latter purpose it is likely that a mixture of alcohol with a more volatile material will be found more generally acceptable, especially as this will enable petrol engines of the existing types to be used without alteration. The proportion of the more volatile constituent could no doubt be progressively decreased as manufacturers make the necessary alterations in their engines. These questions are discussed in detail in *Bulletin No.* 6, *Commonwealth of Australia, Advisory Council of Science and Industry*, 1918, "*Power-Alcohol: Proposals for its Production and Utilisation in Australia.*"

There are other purposes for which alcohol could be employed more extensively than at present, if it were available in sufficient quantities at a cheap rate. Thus it can be used for lighting, either after being "enriched" by the addition of some liquid burning with a luminous flame, or by vaporising it, and burning the vapour in specially constructed burners with incandescent mantles. Heating and cooking appliances have also been made to burn alcohol vapour in place of coal gas.

A number of alcoholic beverages are prepared from cassava in countries where it grows, and it is used in the United Kingdom in the manufacture of spirits. The small percentages of oil and albuminoids which it contains render it very well adapted for brewing purposes; it has been employed on the Continent as a malt adjunct, and an extension of its use for this purpose has been advocated by P. Petit (*Brasserie et Malterie*, 1917, **7**, 129). It was

found that cassava gave good results, but its adoption appears to have been prevented by opposition based on the fact that it yields traces of prussic acid. It is claimed, however, that these traces are eliminated in the process of brewing, and it would appear desirable that this fact should be authoritatively confirmed with a view to the adoption of cassava for this purpose. It is stated to be employed in the same way as rice or maize, but it is desirable to add a small quantity of sulphurous or phosphoric acid (say 3 ozs. of the latter per hundredweight) in order partly to neutralise its alkalinity, as this facilitates liquefaction and subsequent saccharification.

TUNGSTEN ORES: IMPERIAL INSTITUTE MONOGRAPH

The monograph on tungsten ores in the series of Imperial Institute Monographs on Mineral Resources, which has just been published by Mr. John Murray, has been prepared for the Mineral Resources Committee by Mr. R. H. Rastall, M.A., F.G.S., University Lecturer in Economic Geology, Cambridge, and Mr. W. H. Wilcockson, M.A., F.G.S., Lecturer in Geology in the University of Sheffield. It is divided into three chapters, the first containing a general account of tungsten ores, their characters, occurrence and origin, their mining and concentration, valuation and price, with a brief description of the metallurgy of tungsten and its employment in steel manufacture and other purposes, with a short discussion of the composition and characters of the remarkable non-ferrous alloys of which it is a constituent. The second chapter contains a detailed account of the geological features of tungsten deposits, and the mining and production of tungsten ores within the British Empire, including numerous statistical tables of output; while in the third chapter the tungsten resources of the rest of the world are treated in a similar manner. The relations of the British Empire and United States output to the world's total and the production of tungsten ores in the chief producing countries of the world are also shown by means of graphs,

The table giving the world's production of tungsten ores for the years 1910–1917, arranged by countries, shows that the British Empire produces a very large proportion of the total supply. Until about 1910 the United States headed the list, but about that time Burma rapidly came to the front and for several years showed the largest total. In 1916 the United States experienced an extraordinary tungsten boom, when prices soared to unprecedented heights and production was greatly stimulated. This in its turn stimulated the production in various South American States, especially Bolivia and Argentina. Before the war the smelting of tungsten ores was mainly in German hands, and the greater part of the British ore was sent to Germany for treatment. The enormous development of the manufacture of munitions in this country and elsewhere led to a great demand for high-speed steel for cutting tools, and a syndicate of thirty of the largest steel manufacturers at Sheffield formed a company to undertake the preparation of tungsten metal at Widnes. This company also acquired a large and important mine in Burma. The manufacture of metallic tungsten and of ferrotungsten was also undertaken on a large scale by several other firms in this country, in order to make good the failure of the German supply and to provide high-speed steel and other products for the needs of the British and Allied armaments. In order to ensure a sufficient supply of ore and to regulate the markets, the export of tungsten ore from within the Empire to foreign countries was forbidden by agreement of the various Governments concerned and the price was controlled. At first the rate was fixed at 55*s.* per unit (1 per cent. of WO_3) per ton for concentrates of 65 per cent. and upwards, afterwards raised to 60*s.* per unit. This usually worked out to about £200 per ton for good average concentrates. As was naturally to be expected, the world's production of tungsten increased largely during the war years, rising from 8,000 tons or thereabouts in 1914 to over 20,000 tons in 1917. One of the most remarkable features was the sudden development of output in China, from sources of which little is known, the output for 1918 being over 4,000 tons.

In the British Isles wolfram is a by-product of the tin

mines of Cornwall, and the big demand for it proved of great importance to many of these mines. Strenuous efforts were made to keep up the output of both metals in spite of scarcity of labour owing to the demands of the army authorities for men. Several promising new occurrences were developed, and old ones resuscitated. By far the most important feature of the Imperial production of tungsten in the last few years was the great development of the Tavoy district in Tenasserim, Lower Burma, which in 1917 exported no less than 4,553 tons of concentrates. The greater part of this appears to be from various forms of superficial deposits, though lode-mining is now making important progress. In the Malay States, both Federated and Unfederated, as well as in the intervening Siamese territory, the geological conditions are very similar, though here tungsten is subordinate to tin. An important quantity of ore also comes from Queensland and New South Wales, with lesser amounts from Tasmania and New Zealand, the latter Dominion producing mainly scheelite. Some unimportant resources have also been discovered in South Africa, especially in Rhodesia.

The chief European producer is Portugal, while large resources undoubtedly also exist in Spain, where the geological conditions are very similar. In both these countries methods are primitive and often wasteful, and a good deal of smuggling undoubtedly went on during the war.

The tungsten resources of South America are undoubtedly very large, the ore occurring in large quantities along with tin in the mineralised belt of the Andes, especially in Bolivia and Peru; this appears to be of Tertiary age, while the tin-tungsten ores of Western Argentina are of much earlier date, being associated with Palæozoic granites. The mines of Argentina before the war were controlled by German interests.

The tungsten ores of the United States, situated mainly in Colorado, California and Nevada, show a remarkable contrast to those of the rest of the world, in that they are not associated with tin. The largest producing districts of all are Boulder County, Colorado, where the ore is wolframite, and the Atolia district of California, where

it is mainly scheelite. The third producing State is Nevada, while smaller quantities have come from Arizona, Utah, Idaho, Missouri, Montana, South Dakota and Alaska. In the latter only the ore is associated with tin.

The foregoing brief summary indicates the sources from which at the present time supplies of tungsten ore are mainly obtained. Occurrences of little or no commercial importance in many other parts of the world are briefly touched on in the monograph, because in some they show points of scientific interest, and some of them may in the future be found worthy of further development. From a detailed study of the geological features of all known occurrences, one point stands out clearly, namely, that tungsten ores almost invariably owe their genesis to masses of intrusive igneous rock, in nearly all cases granite. Exceptions to this rule are few and important. Almost all the important occurrences are associated with tin, and commonly accompanied by ores of copper, arsenic and molybdenum. It is a curious fact that the world's largest producing districts in Colorado and California should be almost the only exceptional and unusual occurrences.

The monograph concludes with a bibliography giving references to all the important publications on tungsten ores that have appeared up to the end of 1918.

NOTES

Exhibition of the Prince of Wales's Canadian Presents at the Imperial Institute.—H.R.H. the Prince of Wales has arranged for a selection of the presents and addresses received during his recent visit to Canada to be exhibited at the Imperial Institute. The collection is now on view in the Canadian Section of the Public Exhibition Galleries.

The addresses, which number about 200, include those from the Government and People of Canada, and the Provincial Governments and principal cities of Nova Scotia, Prince Edward Island, New Brunswick, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, and British Columbia. Various educational, industrial and other bodies are also represented. There are also addresses, burnt on leather, from tribes of North American Indians.

The presents exhibited comprise the trowel, level and

mallet used by the Prince in laying the corner stone of the main tower of the new Parliament Buildings at Ottawa; gold pass and programme of tour on the Canadian Pacific Railway, with a large-scale map; souvenir photographs, enclosed in a case of bird's-eye maple, from the Grand Trunk Railway; the membership card of the Ottawa branch of the Great War Veterans' Association and the President's badge of the Grand Army of Canada. As souvenirs of visits to important mines are specimens of cobalt, nickel and silver ores from Coniagas Mine, Cobalt; copper and gold ores from Drum Lummon Mine, Douglas Channel, British Columbia; native silver from the O'Brien Mine, Cobalt; gold quartz from the Hollinger Mine, Ontario; and coal from the Wellington Extension Mine, British Columbia.

The presents from native Indian tribes include a chief's suit of buckskin, ornamented with bead-work and a head-dress of eagles' feathers from the Stoney Indian tribe, which are shown on a model, together with a sketch by Captain Pearse of the Prince of Wales wearing this costume as Chief "Morning Star," and a similar photograph signed by the Prince. There are also shown a buckskin coat, fire bag and an album of portraits, presented by the Blackfeet tribe.

Report of the Empire Cotton Growing Committee.—In 1917 the Empire Cotton Growing Committee was appointed by the Board of Trade to investigate the best means of developing cotton growing within the Empire, and to advise the Government as to the necessary measures to be taken for this purpose. The Report of the Committee which has been recently issued as a Parliamentary Paper (Cmd. 523) is divided into two parts, the first dealing with the progress made by the Committee in the study of the Empire's resources for cotton growing, and of their general plans and proposals for their development, whilst the second gives a review of the position and prospects of the industry in the various countries of the Empire which are considered suitable for cotton cultivation.

In Part I it is pointed out that the development of cotton production on an adequate scale depends on (1) the acquisition and application of the necessary knowledge, (2) the institution of efficient arrangements for controlling the cultivation and for marketing the crops to the best advantage of the growers, and (3) the provision of the necessary funds.

With regard to (1) the need for research on both the agricultural and manufacturing sides is discussed, and a

proposal is made that a Central Research Institute should be established, possibly in Egypt, which should co-operate with the bodies at work in other cotton-growing countries, such as the West Indies, and also with the British Cotton Industry Research Association. In connection with the application of knowledge, it is recommended that considerable additions should be made to the various Agricultural Departments of the British Colonies and Dependencies, and that the Colonial Office should appoint a small committee to consider the question. In order to increase the supply of men capable of carrying out investigations on scientific problems, it is suggested that provision should be made for at least four readerships at British Universities in plant physiology, plant genetics, mycology, and entomology, and that a series of research studentships should be established to be held for either one or two years by graduates for training in methods of research in these and allied sciences.

Reference is made to the valuable pioneer work of the British Cotton Growing Association, and it is pointed out that such work will continue to be required for determining the possibilities of new areas, and for preliminary trials in the more promising localities.

The Committee consider it desirable that they should establish a Central Bureau of Information for the collection and dissemination of knowledge relating to cotton and its cultivation. In this connection they refer to the assistance given for many years by the Imperial Institute in the face of many difficulties and express the hope that they may be able to work in fruitful and harmonious co-operation with the Institute. A Memorandum by Professor Wyndham Dunstan, C.M.G., F.R.S., on the "Work of the Imperial Institute in Connection with British Cotton Cultivation" is appended to the Report (see this BULLETIN, 1918, **16**, 79). The Committee are also considering the question of issuing a Quarterly Review of Cotton Growing to serve as a record of progress in the cotton industry, and to provide information on all matters of interest to cotton planters.

With reference to (2), the importance of seed control is discussed in relation to the maintenance of the purity of the cotton and the elimination of disease. Emphasis is laid on the need for the enactment and enforcement of compulsory measures to prevent the spread of cotton pests, and it is pointed out that the methods of control in each country must be adapted to the local conditions. It is recommended that the Governments of all cotton-growing areas in the Empire should be advised to take full powers

for exercising strict control over all essential matters connected with the crop, and should also take steps, where desirable, to establish local associations of cotton growers to advise them on all matters of general interest to the industry.

The necessity for good marketing is considered, and it is shown that, in the case of a new industry, it is desirable that it should be fostered by a disinterested buying agency. The Committee recommend that arrangements should be made for the British Cotton Growing Association to act as their agent for marketing the crops when this is desired by the local Government, and that the Association should forgo any profits arising from such business, provided that they are guaranteed against any permanent loss.

With regard to (3) the Committee show that considerable annual expenditure will be needed not only to finance and market the crops, but also to provide better means of transport, and to carry out schemes of irrigation and drainage. The provision of funds will also be required in connection with the proposed Central Research Institute, for the establishment of readerships and studentships, for pioneer work in new countries, and for other purposes. It is suggested that the necessary sums should be provided from (*a*) the British Treasury, (*b*) the local revenues of cotton-growing areas, and (*c*) the British cotton industry by means of some contributory scheme, such, for example, as a small levy on each bale of cotton imported.

The Committee also recommend that they should be authorised to continue their work on the lines of the present Report, and that a grant of £10,000 per annum for five years should be made by the Treasury to provide for secretarial and current expenses, and for any outlay that may be needed for initiating work in connection with the objects for which the Committee was appointed.

In Part II of the Report a brief survey is made of the cotton-growing areas of the British Empire, and an account is given of the conditions prevailing in the various countries and the position and prospects of the cotton industry. Much of the information afforded is already familiar to readers of this BULLETIN. The countries are dealt with in the following order: West Indies, Egypt, Sudan, Mesopotamia, Uganda, East Africa, Nyasaland, Rhodesia, Union of South Africa, Nigeria, India, Queensland, and Oceania. Special recommendations are made in respect of each of these countries, with reference to such matters as the enlargement of the staff of the Agricultural Department, improvement of the varieties of cotton grown, irrigation

and drainage projects, control of insect pests, transport facilities, marketing of the crops, and the exploration of new areas.

Cotton Growing in Cambodia.—An interesting account of this subject has been published as *Bulletin No. 5, Série Saigon, Gouvernement Général de l'Indochine*, entitled "Possibilités du Cambodge au Point de Vue Cotonnier," by M. de Flacourt, Chef des Services agricoles et commerciaux au Cambodge.

The cotton plant is widely distributed in Cambodia, and the four following varieties are met with: (1) "Krabas" or "Krabas bay" a form of *Gossypium hirsutum*, Linn., which is commonly known as Cambodia cotton. This is the only variety cultivated on a large scale on the banks of the Mekong and Bassac and their principal tributaries, and is the Cambodia cotton which was introduced into British India some years ago and has been grown with such marked success. (2) "Krabas Tés" (*G. acuminatum*, Roxb.). (3) "Krabas Sámrê" or "Krabas Sangké," a type intermediate between *G. arboreum*, Linn. and *G. indicum*, Lam., but which according to recent determinations is rather to be regarded as a form of *G. arboreum.* (4) "Krabas Sampau," the botanical origin of which has not yet been precisely determined.

The first variety is by far the most important cotton of Cambodia, both in respect of the area cultivated and the large quantities of cotton obtained from it. The area planted annually with this type varies from about 13,000 to 20,000 hectares (32,000 to 50,000 acres), depending on the height to which the rivers rise. The cotton plant has to compete on the sloping river banks with various other crops, such as mulberry, tobacco, beans, maize, castor seed, ground nut and sesamum, and its cultivation on these banks is not capable of great extension. If, however, protection against the inundations could be provided by means of dams to the flat land which extends back from the rivers and principal water-courses, the area available for cotton could be greatly increased.

The production of seed-cotton in Cambodia during the years 1912–1917 was as follows (in metric tons); 1912, 7,000; 1913, 6,000; 1914, 8,000; 1915, 3,000; 1916, 5,000; 1917, 5,000. Most of the cotton is ginned at the Khsach-Kandal ginnery and is exported *viâ* Saigon to Japan, either directly or through Hong Kong.

On the inundated lands, the native growers cannot choose their time for planting but are dependent on the overflow of the rivers. The seed is sown after the floods

have subsided and when no return of the inundation is to be expected; this usually occurs between the end of October and the beginning of December, and coincides with the termination of the rainy season. In these circumstances the crop cannot be grown to the greatest advantage. If the rainy season is late, and the cold of winter commences early, the plants, insufficiently rooted, are completely checked in their development at an early stage of growth. On the other hand, if the rains are very abundant during March, April and May (which not uncommonly happens in Cambodia), the crop, which does not begin to mature until the end of February, is injuriously affected both in quality and yield. The cotton produced under these conditions is short (0·7–0·9 in.), irregular and woolly, and contains numerous small, undeveloped seeds.

After studying these drawbacks to the industry, the local Technical Service have undertaken researches into the possibility of utilising other lands for cotton cultivation with a view to the production of cotton of a better quality, and an attempt has been made to adapt the plant to lands sufficiently elevated to escape inundation. There are about 8,000,000 to 10,000,000 hectares (20,000,000 to 25,000,000 acres) of such land in Cambodia which are in the form of either slightly sloping plateaux, more or less irregular dales, or extensive plains. Trials which were commenced in 1913 have proved that Cambodia cotton is well suited for such lands and yields a fibre of better quality than that produced on the river banks. On such non-inundated areas, the cotton can be planted at the end of July or the beginning of August, and obtains the benefit of the rains (August–November) which enable it to become well rooted and to develop vigorously. The plants begin to flower early in November, and the bolls begin to ripen at the end of December, so that picking can be carried on from the end of December to the end of March. The plants bear an abundant crop of bolls, and as January and February are the driest months of the year, the bolls ripen under the best conditions. The cotton produced is much superior to that grown on the river banks; it is more regular, less woolly, free from aborted seeds and of greater length (average about 0·95–1·15 in.). This product has been reported on favourably by commercial and industrial experts, who state that it is quite suitable for the French industry, and could be used for spinning yarns of medium counts, whereas the cotton grown on the river banks could not be employed in France unless the existing machinery was modified or special machinery introduced.

As already stated, the trials commenced in 1913 gave

satisfactory results, and in order to encourage the natives to undertake cotton growing on the higher lands, two demonstration farms were established in 1915, one at the village of Chambâk-Méas, in the Province of Stung-Trang, and the other at the village of Thbong-Krapœu, in the Province of Kompong-Svaï. These two farms have an altitude such that they are completely exempt from inundation. The cultivation was conducted with the help of the natives and without irrigation or manuring.

The nature and composition of the soil of these two areas differ widely ; the soil of Chambâk-Méas is red, and that of Thbong-Krapœu grey. During four consecutive years (1913–1917) the cotton was found to grow equally well on either of these soils, and in each case the annual yield was about the same, and did not vary as it does on the inundated lands.

During the rainy season of 1916, 16½ hectares (41 acres) of the red soil in the Province of Kompong-Siem were planted by the natives on their own initiative. This area consisted of fifty scattered plots, which were neither manured nor irrigated and yielded a total crop of 10½ metric tons of seed-cotton or an average of about 638 kilograms per hectare (or 570 lb. per acre). On ginning, the cotton yielded 34 per cent. of lint of good quality. The success of this effort illustrates the influence which demonstration plots can have on the native population in encouraging them to extend the cultivation. As a further encouragement to the natives, it is intended to arrange for the free distribution of selected seed, to stimulate a spirit of emulation by offering prizes for the best crops, and to hold markets at fixed periods, which will tend to check the exploitation of the natives by small Chinese traders, and enable the cotton to be sold direct to exporters, manufacturers or mercantile houses, either European or Asiatic.

It is estimated that there are at least 2,000,000 hectares (5,000,000 acres) of the red lands in Cambodia with an altitude of 60–125 metres (200–420 feet). The attention of the local Technical Service has been directed to certain regions which are comparatively easily accessible and have a total area of over 600,000 hectares (1,500,000 acres). One of these regions is on the right bank of the Mekong, to the north of Kompong-Cham, and the others are situated on the left bank of the river in the Provinces of Thbong-Khmum and Chhlong.

There is no European agricultural enterprise in Cambodia at present, but it is of importance to the development of the country that this should be undertaken as soon

as possible. On the red lands referred to above there are numerous villages which, although not sufficiently populated to provide the labour necessary for such vast areas, possess a suitable labour supply for the commencement of the industry. In view, however, of the small population (about 1,700,000 persons for a total area of over 175,000 square kilometres or 70,000 sq. miles) and its unequal distribution, the question of importing foreign labour has had to be considered in connection with the subject of future European colonisation. The local Administration has arrived at the conclusion that the problem could best be solved by Indian immigration on account of the common origin and religion of the Cambodian and Hindu and the similarity of their manners and customs. It is evident that private initiative, either in the development of the large areas of land which are still available for disposal or in the establishment of ginning or oil-extracting industries, could contribute greatly to the agricultural development of the country, and at the same time furnish raw material for French industries which are at present dependent on foreign sources of supply.

In concluding his report, M. de Flacourt points out that the warm and dry climate of Cambodia, its rich and fertile soil, its enormous areas which still await disposal, its population, which is essentially agricultural and of a peaceful and submissive disposition, its numerous and well-kept roads, and its natural resources constitute a series of advantages which fully justify a serious effort to advance its economic development. European activity is assured of abundant opportunities, both agricultural and industrial, if the labour question can be solved on the lines already indicated. With regard to cotton in particular, emphasis is laid on the fact that the crop which is now beginning to be produced on the non-inundated lands—which are the only lands on which the cultivation can be greatly extended, and on which European agricultural development can succeed—has been pronounced as good as the American kinds which are annually imported into France in large quantities. In connection with the production of cotton on a large commercial scale, whether by natives or Europeans, it is necessary that a ginning industry should be established, and it is also desirable that oil mills should be erected for the extraction of cotton seed oil.

Experimental Cultivation of Buchu in South Africa.—The buchu leaves official in the British Pharmacopœia (1914) are derived from *Barosma betulina*, Bart. and Wendl.,

a shrubby plant belonging to the Rutaceæ and found only in South Africa. Preparations of the leaves are used medicinally chiefly in urinary diseases. The leaves contain an essential oil rich in the so-called barosma camphor (diosphenol), to which they owe their medicinal properties. From their shape, they are frequently known as "round" or "short" buchu. Two other species, *B. crenulata*, Hook. ("oval" buchu) and *B. serratifolia*, Willd. ("long" buchu), were at one time official in the British Pharmacopœia, but the oils from them contain a smaller proportion of diosphenol. They are consequently less valuable than "round" buchu, but nevertheless are still exported from South Africa for use in medicine.

During the ten years prior to 1913 the annual exports of buchu leaves of all kinds from South Africa amounted to about 250,000 lb., the value of the exports towards the end of this period being about £30,000 per annum. From 1913 onwards, the exports declined, the quantity and value during the last six years for which figures are available being as follows: 1913, 163,812 lb., £32,071; 1914, 149,113 lb., £27,558; 1915, 157,061 lb., £23,767; 1916, 130,794 lb., £21,685; 1917, 124,110 lb., £20,154; 1918, 89,675 lb., £16,948. Practically all the buchu leaves exported in recent years have been shipped to the United Kingdom and the United States, but it is stated that the bulk of the material reaching this country eventually finds its way to the latter country (*South African Journal of Industries*, 1917, **1**, 57).

Hitherto all the leaves have been collected from wild plants, the branches being usually pulled off so as to leave a jagged wound, which takes some time to heal. With this method of gathering it is only possible to harvest the leaves from a particular plant once in two years, and sometimes the damage is so great that the plant dies outright. Even if the plants live, the continual removal of the branches prevents the formation of seed, so that there is a possibility of the plant eventually being exterminated in a wild state.

To prevent the wholesale destruction of the plants the Buchu Protection Ordinance was passed by the Cape Provincial Council in 1913 and regulations were published dealing with the granting of permits for picking buchu. In 1915 a Government Notice was issued prohibiting the picking of buchu on Crown lands and the Forest Reserves in the Cape Province, during the period March 16 and January 14, both dates inclusive.

Although these measures will doubtless help to preserve the wild plants from extermination, there is no question that the best way to obtain a continuous and regular supply

of the leaves is by cultivating the plants. A further advantage of cultivation is that it would ensure the leaves being marketed in a pure state. At present the three standard forms of buchu are sometimes found to be adulterated with leaves of other species of *Barosma*, whilst those of *Empleurum serrulatum* are occasionally present in considerable quantities in parcels of long buchu (*B. serratifolia*).

Cultivation experiments with buchu have been made from time to time by private persons (see for example *Agric. Journ. Union of S. Africa*, 1913, **6**, 80), and more recently experiments with *B. betulina* have been conducted at the National Botanic Gardens, Kirstenbosch, particulars of which are given in the *South African Journal of Industries* (1919, **2**, 748). Seed was sown in 1914 in four plots situated in different positions on the slopes of Wynberg Hill. At the base of the slope, where the soil consisted mainly of a black sandy alluvium, which was occasionally flooded during the winter, only a few seeds germinated at the driest end, and these did not survive the first winter. The best results were obtained on a plot in an open sunny position well up the slope of the hill. Here the soil was a red, gritty loam, rich in iron and deficient in lime, the subsoil being dry and consisting of clay containing a large quantity of quartz grit, with here and there a seam of ironstone gravel. In June 1916 a further sowing was made at this spot in rows 4 feet apart, the land being trenched and no manures added. About 80 per cent. of the seed germinated in this case, which was much higher than in any previous sowings. The germination, however, was slow. Seed was also sown in tins in a nursery, to supply plants for filling gaps in the plantation, but not more than 20 per cent. germinated. The seed sown *in situ* was not watered, and rain fell on only two days in the first fortnight, whereas the surface soil in the nursery was kept moist by watering. It appears therefore that the seed dislikes much moisture during germination. When twelve months old the seedlings were thinned out, and some were transplanted, but not more than 10 per cent. succeeded. At two years old the plants sown in 1916 were from 12 to 18 inches high, very bushy, and some of them flowered and seeded.

It is suggested that the best method of harvesting is to cut the whole plant back to near the crown when eighteen months old, and thereafter annually, cutting each season a little above the previous year's cut. By this method a harvest is obtained every year, and the yield should gradually increase. It would be necessary, however, to allow a number of plants to grow on and flower,

in order to obtain seed for the renewal or extension of the plantation.

The yield of dry leaves from a row 80 yards long, cut in May 1918, that is when the plants were about two years old, was 8½ lb. With rows 4 ft. apart this is equivalent to a yield of about 400 lb. per acre. It is stated that the growth of the plants subsequent to being cut back was entirely satisfactory, and none of them died.

The results obtained in the experiments at Kirstenbosch indicate that under suitable conditions the commercial cultivation of buchu should prove a success. *B. betulina*, the most valuable kind, alone should be grown. The plant is particularly adapted to dry conditions, and may be planted on sunny hillsides, where other crops will not succeed.

The "Lumbang" Oil (Candlenut Oil) Industry in the Philippine Islands.—According to Aguilar (*Philippine Journ. Sci.*, 1919, **14**, 275), two kinds of "lumbang" nuts are known in the Philippine Islands—"lumbang bato," *Aleurites moluccana*, and "lumbang banucalag," *Aleurites trisperma*. The former is more widely distributed and is the source of commercial lumbang oil. The other variety has the reputation of causing skin eruptions, and the merchants are averse to handling it. The manufacture of lumbang oil has been carried on in a crude way, chiefly by Chinese, for a long period, but the oil industry is now undergoing change; improved methods are being adopted, and some of the large local coconut oil factories are paying attention to lumbang oil. In the past it was thought that the available supplies of lumbang nuts were insufficient to induce merchants to invest capital in the industry, later it appeared that considerable quantities of nuts could be obtained, and in 1910 it was stated that sufficient seed could be obtained from Laguna, Tayabas and Batangas to render the installation of machinery near San Pablo, Laguna, a profitable undertaking. Information now available indicates that the supplies of nuts from Mindanao, especially in the Davao Gulf district, where large quantities of nuts are now left to waste, could be increased largely.

Any accurate estimate of the crop of lumbang nuts is difficult, but as long ago as 1911 one manufacturer claimed that it would be possible to supply a modern oil mill, working over 230 metric tons of kernels a month; and it is estimated that owing to the efforts of the Bureau of Forestry to encourage planting, about half a million trees a year are being planted, so that an increasing supply of

nuts is assured. The fruits mature in June and July, and are best collected during July and August.

Lumbang oil is at present used in the Philippine Islands for caulking vessels, for soft-soap manufacture and for paints, while the demand for the oil by paint manufacturers in the United States is much in excess of present supplies.

The removal of the kernels from the hard woody shells is somewhat difficult and in some cases the whole nuts are crushed and the oil expressed. In the latter process the yield of oil is lower, and the value of the residual cake is much less than when the kernels only are worked, while the output of oil and cake from whole nuts would be less and the labour involved greater than with kernels worked in the same factory. No mention is made of the possibility of extracting the oil from the whole nuts by the solvent process, though this process would enable all the oil to be extracted and yield a cake free from oil and therefore preferable for use as a fertiliser.

Various methods, all more or less troublesome, of removing the hard nut-shells (comprising about 66 per cent. of the nuts) are employed. By sun-drying of the nuts, followed by cracking, most of the kernels are obtained unbroken and are of good quality, but the process is tedious. In Laguna, Tayabas and Batangas the nuts are placed in tanks of boiling water and left for five or six hours; by this means the kernel is loosened in the shell, and after cooling the nuts are cracked. In some localities the Chinese cover the nuts with straw, which is then burned and the nuts immediately sprinkled with cold water, when, it is claimed, the nuts burst. In the two last-mentioned cases the kernels are of brown colour, owing to long heating, and yield brown oil, so that the kernels are inferior to those obtained from sun-dried nuts. A method worked out by the Bureau of Science consists in heating the nuts in an oven to 95° C. for three or four hours, after which they are thrown into cold water and left overnight; it is stated that the shells burst, and can be separated without difficulty from the kernels, which yield oil of good quality. The method employed for removing the shell is of great importance, as the oils from the brown, heated kernels are of dark colour, and contain large amounts of free fatty acids, compared with oils from fresh kernels.

The "lumbang bato" nuts can be stored for a year or more in a cool dry place without appreciable alteration in the amount or quality of the oil, but prolonged storage of the kernels is undesirable, as the oil becomes more acid and the kernels are liable to attack by insects.

The "lumbang banucalag" kernels rapidly deteriorate

even when stored in the form of whole nuts; they have a much thinner shell than the "bato" nuts, and yield an oil closely related in character to Chinese wood oil (T'ung oil, cf. this BULLETIN, 1913, **11**, 441).

It is recommended that efforts should be made to produce commercial supplies of "banucalag" oil. The difficulties of working this oil owing to deterioration of kernels during storage could be obviated by working up the "banucalag" nuts early in the season, and storing the "bato" nuts, which do not deteriorate, for future use.

It is of interest to note that *Aleurites moluccana*, the "candlenut" tree, is widely distributed in the tropics and occurs in, or has been introduced into, a number of British possessions, from which samples of candlenuts, kernels and of oil have been received at the Imperial Institute from time to time and submitted to examination (cf. this BULLETIN, 1907, **5**, 134; 1912, **10**, 44), although no appreciable quantities of kernels or of oil have appeared on the markets in the United Kingdom.

In view of the demand which has arisen for the oil in the United States it seems desirable to recommend the collection of nuts in all British Colonies where they can be obtained in any quantity so that efforts can be made to introduce this oil to the notice of British manufacturers. It would obviously be undesirable to ship the whole nuts, which consist of only about 34 per cent. of kernel; the nuts should be dried and cracked, and the kernels only shipped. It appears unlikely that the kernels will deteriorate if properly dried and shipped without undue delay. The value of the kernels and of the oil in the United Kingdom is somewhat uncertain, but there seems no doubt, in view of the very high price of linseed oil at the present time, viz. about £126 per ton, that kernels or oil of good quality would meet with a ready sale if regular shipments of 100 tons or more at a time could be obtained.

RECENT PROGRESS IN AGRICULTURE AND THE DEVELOPMENT OF NATURAL RESOURCES

In this section of the Bulletin *a summary is given of the contents of the more important papers and reports received during the preceding quarter, in so far as these relate to tropical agriculture and the utilisation of the natural resources of the Colonies, India and the Tropics generally. It must be understood that the Imperial Institute accepts no responsibility for the opinions expressed in the papers and reports summarised.*

AGRICULTURE

Foodstuffs

Chicory.—Trials have been made as to the possibilities of chicory as a crop for the Bombay Presidency. In 1917–18 the plant was grown under the direction of the Deputy Director of Agriculture, Northern Division, at Nadiad, Broach, Amalsad and Dohad, and did well in all these places except Dohad (*Ann. Rep. Dept. Agric., Bombay Presidency*, 1917–18). The highest yield was obtained at Nadiad, where it amounted to 13,900 lb. per acre, while at Broach and Amalsad the yields were 7,210 lb. and 6,800 lb. respectively. Chicory is well adapted to alluvial soil and would be a valuable addition to the crops of Gujerat if it can be sold at a remunerative price. During the year 1917–18, 33,170 lb. of the fresh roots were disposed of and realised R. 2,073 15 as. (£138 5*s.* 3*d.* at normal rate of exchange). Much interest has been aroused among the cultivators at Nadiad and Broach, and applications have been made to the Department of Agriculture for seed and plants.

Coffee.—In the *Agric. Journ. of India* (1919, **14**, 578) an account is given of "The Coffee-planting Industry in Southern India" by Rudolph D. Anstead, M.A., Deputy Director of Agriculture, Planting Districts, Madras. After referring to the introduction and history of coffee growing in Mysore and Coorg, it is pointed out that the decline in the industry which took place between 1883 and 1898 was due partly to the fall in the price of coffee caused by Brazilian competition and partly by the ravages of diseases, especially leaf disease, produced by *Hemileia vastatrix*, and root diseases. Many of the best estates survived, however, and as the situation improved the area was increased. At the present time the area devoted to coffee in Southern India is 223,095 acres, distributed as follows: Madras Presidency, 48,441 acres; Coorg, 42,654; Mysore State,

122,500; Travancore State, 7,000; and Cochin State, 2,500 acres. In Mysore and Coorg, the acreage is divided among Europeans and Indians approximately as shown below:

Coorg	*Acres.*
Area under cultivation by Indians on European lines	17,809
Area under cultivation by Indians on native lines	3,625
Area under cultivation by Europeans	21,220

Mysore	
Area under cultivation by Indians	101,255
Area under cultivation by Europeans	21,245

During recent years increased attention has been directed to the scientific cultivation of the crop, and since the establishment of the Scientific Department of the United Planters' Association of Southern India in 1909 methods of controlling diseases and systematic schemes of manuring have been widely adopted. The coffee on many of the estates is very old and will shortly have to be replaced. An important change has already taken place in the substitution of the hardy and robust Coorg strain for the old "Chick" coffee. It has lately been realised that there is a need for better seed selection, and for studying the possibility of raising a new vigorous strain of coffee by hybridisation on Mendelian lines. The matter has been taken up by some of the more enlightened planters and a hybrid has been obtained which has all the vigour of the old Coorg type, is highly resistant to disease, and gives a much larger yield than the ordinary kind now generally cultivated. This hybrid is now being grown on a commercial scale, and is expected to have an important future.

Most of the coffee grown in Southern India is of the *Coffea arabica* variety, but some *C. robusta* has been planted recently. The latter is gaining in popularity on poor soils and as a catch crop among Para rubber trees; it bears heavily and, although it produces an inferior grade of bean, it will doubtless be grown in many places as a subsidiary crop.

Advances have been made recently in the machinery employed for preparing the coffee for the market. In place of the bullock power which used to be employed for driving the pulper, oil-engines are now used on most estates, and modern pulpers have been installed together with improved arrangements for washing the coffee. On one estate a dryer has been introduced in which the washed

parchment coffee is dried by means of hot air in a revolving drum. The final curing of the coffee is conducted by curing firms at the coast where a hot sun is available. It is pointed out that an improvement in this respect could be effected by the co-operation of coffee planters in establishing their own curing works to which the coffee would be sent after having been reduced to a comparatively dry state in artificial dryers. A coffee experiment station is being established in Coorg on the lines of a Government farm where a study will be made of manuring problems, methods of cultivation and disease control, and possibly also of plant breeding.

The coffee industry of Southern India is, on the whole, in a very flourishing condition, and has excellent prospects, as it is capable of producing high grades of coffee for which there is a constant demand in the European markets.

Maple Sugar.—In the *Agric. Gazette of Canada* (1919, **6**, 959) an account is given of the maple-sugar industry of the Province of Quebec. It is estimated that the quantity of maple sugar manufactured in the Province during 1919 amounted to about 30,000,000 lb. as compared with about 10,000,000 lb. in 1911. The great development which has taken place during the last few years is mainly due to the scarcity of cane and beet sugar, and the continued rise in the prices of these products. It is considered, however, that the increased production of maple sugar has been greatly stimulated by the work of the sugar schools which have been established by the Department of Agriculture and by the demonstrations which have been given in all parts of the Province by special instructors appointed by the Department. There are three sugar schools now at work, one at La Minerve, Labelle County, another at Beauce, Beauce County, and the third at Ste. Louise, L'Islet County. Modern methods of sugar and syrup making are taught in a practical manner at these schools, and the Department pays for the board of the students, who may take a course of lessons extending over eight, ten or fifteen days. The schools are equipped with modern evaporators and appliances, and the utmost cleanliness is observed in all the operations. In 1919 ninety-four demonstrations were given in eighteen counties of the province by five instructors. The sugar makers assemble in one of the sugar groves, and the methods of sugar manufacture are demonstrated, the makers being given any information for which they care to ask. These demonstrations have been very successful, and have resulted in 75 per cent. of the sugar manufactured being of the first quality.

Palm Sugar.—In the *Rep. Dept. Agric., Bombay Presidency for* 1917–18 an account is given of trials which have been carried out on the manufacture of "gul" from certain palms. It was found that the wild date palm (*Phœnix sylvestris*) which grows abundantly in the North Thana could be made to furnish solid blocks, resembling cane "gul," throughout the tapping season, except on very cloudy days, when it became rather soft. The following conditions were found necessary to ensure success: (1) a short tapping period, not exceeding two or three days, followed by a period of rest of three or four days so that the surface of the cut may dry and the ferments be rendered inactive; (2) scrupulous cleaning of the surface of the cut; and (3) liming and smoking of the pots used for collecting the juice; smoking was observed to be even more effective than liming, and much cheaper. Unfortunately the "gul" develops a dark colour on keeping, and efforts are therefore being made to find means of obviating this defect. During the tapping season, 400 trees which were under operation throughout the whole period yielded 11,966 gallons of juice which furnished 13,831 lb. of gul, of which 28 per cent. was solid and hard, whilst the rest was a soft solid. After selling the "gul," the net profit amounted to R.1 as.8 p.6 per tree. The prices realised were abnormally high, and it is anticipated that with a return to normal conditions the profits on a manufacturing scale will be only about 7 annas per tree.

In the Kanara district, some trials were made on the preparation of "gul" from coconut palms, and one tapper, working on twelve trees, obtained an average yield of 35 lb., of value Rs. 5 per tree in nine months.

An experiment was made in the Kolaba district to obtain "gul" from the "bherli mad" palm (*Caryota urens*). A small quantity of dark-coloured solid "gul" was produced from the juice of the tree, but the yield was too small to be remunerative.

Oils and Oil Seeds

Coconuts.—A small plot of coconuts was planted out in 1916 near the river at Ilorin in the Northern Provinces of Nigeria; this was handed over to a native farmer who has grown the usual crops on the land. The trees have grown very well on the higher level, but not so well near the river, where the soil becomes flooded during heavy rains (*Ann. Rept., Agric. Dept., N. Provs., Nigeria*, 1918, p. 18). An acre of land was planted on the experiment

farm in 1918 on light sandy soil, and the plants were doing well during their first season, which was a dry one.

The coconut is distributed over the greater part of Cochin-China, being grown on a small scale near the villages and native houses, and also in regular plantations. The area of the latter cultivated by natives in Lower Cochin-China amounts to about 17,500 acres, whilst about 2,500 acres are under cultivation by Chinese and Europeans (*Congrès d'Agric. Colon., Saigon, Bulletin No.* 11, 1918, p. 13). The exportation of copra during recent years has been small owing to difficulties of shipment; the average yearly export per year during 1910–1914 was about 7,000 metric tons, whilst only 2,000 tons were exported from Saigon in 1917. An oil mill (Soc. des Huileries de Saigon) was established in Saigon in 1917, capable of utilising 2,000 tons of copra a year. Under normal conditions an export of 8,000–10,000 tons a year should be available. It is estimated that there are about 375,000 acres suitable for coconut plantations.

Regulations are in force requiring the notification of diseases and pests, the destruction of such pests as *Rhinoceros* and *Rhyncophorus* beetles and of badly attacked trees.

Native plantations are as a rule too closely planted (about 15–18 feet), those under European control are better (about 27–33 feet). The 7,000 tons of copra exported comes entirely from the region of Mytho-Bentré from an area of about 17,500 acres; the yield amounts therefore to only about 0·25 ton of copra per acre, and could be increased by better cultivation and spacing. The copra produced by the planters is insufficiently dried and generally has to be redried by merchants before exportation. The prospects in Cochin-China appear sufficiently promising to warrant extended cultivation.

In Grenada coconut trees on the experimental plot planted in 1912 at Westerhall have been attacked by a disease caused by nematode worms; a few trees died in 1915, and up to May 1919 over 25 per cent. of the trees had died (*Minutes of Special General Meeting of Agric. and Commercial Society, Grenada*, May 9, 1919). Trees which are attacked show the following symptoms: the outer or older leaves dry up, the green colour of the tips of the leaves changing through bronze-green to yellow; gradually the other leaves also die, and when the disease has reached the "heart" or "cabbage," this is often attacked by the palm-weevil or by putrefactive bacteria, and dies. Often a firm brown wet rot occurs in patches on the expanded leaf base, and on cutting through a diseased tree a well-

marked red ring from ¾ to 1½ in. in width is found situated at about 1½ in. from the periphery of the stem. This red-ring zone is the part of the stem infested by nematodes, which also occur in the roots and in the petioles. The disease is a very dangerous one, as no attacked trees have been known to recover, and it rapidly produces serious effects, trees inoculated in the stem showing signs of dying within sixty days. Until more is known of the means of infection and life-history of the nematode, it is not possible to recommend preventive measures other than destruction of all diseased trees and the division of coconut plantations showing the disease into squares, each carrying a single tree, by means of narrow deep drains. In the past this disease has been known as the "Trinidad root disease," but as it is now known to attack other parts of the palm than the roots and occurs outside Trinidad it is now proposed to call it the "Red-ring" disease.

Linseed.—Flax was grown during 1918 in Scotland under an arrangement between the Board of Agriculture for Scotland and the Flax Production Branch of the Board of Agriculture and Fisheries, about 1,300 acres of flax being grown in Fife (*Scottish Journ. Agric.*, 1919, **2**, 491).

The crop was grown for the sake of the fibre, but experiments show that, as in the case of English-grown flax (cf. this BULLETIN, 1919, **17**, 431), the seed produced was of good quality. The seed sown was Dutch and contained 39·2 per cent. of oil; sixteen samples of clean seed grown in Scotland from this seed contained from 34·7 to 38·6 per cent. of oil, with an average of 36·2 per cent. The average yield of seed per acre in Fife was 15 bushels (52 lb. per bushel).

A factor which has militated against the cultivation of flax in the past is the popular belief that the crop is exhausting to the soil, in fact clauses have been introduced into farm leases restricting the farmers from cultivating flax. Careful records and chemical analyses of the crops obtained show that the amounts of nitrogen, phosphoric acid and potash removed from the soil by a crop of flax are about the same as in the case of average cereal crops. It is suggested that the reputation borne by flax of being an exhaustive crop is due to the fact that in harvesting it is usual to pull the plants including the roots. The experimental data show that, although the stems and roots comprise the greater part of the weight of the crop, they do not remove from the soil such large amounts of manurial constituents as are contained in the capsules and seed, and

if the latter are consumed on the farm and the manure returned to the land depletion of the soil is not so great as when cereal straw is sold.

Candelilla Wax.—During 1918 there were about twenty-five factories in the Monterey district of Mexico producing Candelilla wax (cf. this BULLETIN, 1912, **10**, 128, 669). The wax is obtained from the plants by boiling in wooden tanks with water to which sulphuric acid is added; the wax rises to the surface and is collected, and again treated with sulphuric acid, and finally run into moulds (*Supplement to U.S. Commerce Repts., Annual Series, No.* 32 C, October 30, 1919, p. 18). During the year the price dropped from 45 to about 30 cents. per lb. f.o.b. Laredo, Texas. The wax exported to the United States in 1918 was valued at $144,907 (£30,189 at normal rate of exchange).

RUBBER

Hevea

Borneo.—Some interesting notes on rubber planting on the west coast of Borneo have been published by de Neve (*Indische Mercuur*, March 7, 1919; *India-Rubber World*, 1919, **60**, 722). Seeds imported from Malacca were first planted in Pontianac in 1903 by Chinese and by an Englishman, A. Simons. The oldest trees in the island are those planted by Simons at Bengkalon in the Kapoewas district, and the plantations at Pontianac now afford work to hundreds of coolies and tappers, while seedling plants are conveyed by river in small Chinese boats to the upper districts. In 1917, owing to the low price of rubber, Europeans did not enlarge their plantations, but the islanders increased the area under rubber very considerably. The lack of labour which has caused difficulties on the larger plantations does not affect the native planters seriously, as they make use of children and relatives. In 1917, 2,970,240 lb. of rubber were exported, of which only about 560,000 lb. were produced by plantations owned by Europeans.

On ordinary soils, containing 50 to 65 per cent. of sand, the production is good; in Pernatang soils, where the sand amounts to 85 per cent., the growth of trees is more rapid and the bark thinner and harder than on rich and old peat soil. Plant diseases are absent on the sandy soil, and the production is above the average, apparently owing to the ease with which such soils drain after flooding, and to the fact that though the surface becomes very dry during long periods of drought, these soils remain moist

underneath. Vegetables and even sugar cane are grown as catch-crops.

Plant diseases are not numerous on the west coast of Borneo, striped canker and " knobbed canker " being the most important. The methods of preparation are in many cases primitive, alum being used a good deal as a coagulant owing to the high price of acetic acid, while adulteration of Hevea with other rubbers was common at the commencement. Little attention appears to be paid to packing or grading, sheet from various sources being tied in bundles and sold in Pontianac, where Japanese buyers have lately entered the market.

Reference to the prospects of rubber planting in Dutch West Borneo is also made in an article by Evans (*India-Rubber World*, 1919, **61**, 54). The soil and conditions appear to be favourable as the trees grow rapidly and yield well; on one estate which was poorly managed seven-year-old trees, which were planted too closely, and not thinned, yielded an average of 3·65 lb. of rubber per tree per year, whilst an exceptionally well-kept Chinese plantation gave 5·28 lb. per tree from trees six to seven years old. This author states that, though labour conditions are not ideal, they compare favourably with those in the Federated Malay States, and that the Dyaks are adapted for heavy work, *e.g.* felling jungle, whilst Malays are useful for the lighter work of weeding, tapping and the preparation of rubber. Estates at present depend on local labour, but a large increase in planting might make immigration necessary. Transport facilities are not generally good, but cheap river transport is available for plantations near the rivers. The cost of production is approximately the same as in Java.

Selection and Propagation of Trees.—In an article entitled " Better Rubber Trees," Romein (*India-Rubber World*, 1919, **61**, 5) calls attention to the great variability in yield of rubber of individual trees, and the desirability of propagating only trees that give high yields of rubber. The author quotes a striking example of the variability of yield where 250 trees were tapped, and the yield over a period determined separately for each tree. The lowest yield was 16 grammes, and the highest 342 grammes of dry rubber per tree, the average being 66 grammes.

In attempting to propagate Hevea trees of an improved type, high yield of rubber is not the only important factor; resistance to disease and quality of rubber are also important, though comparatively little is yet known about the quality of rubber from different trees.

The methods which could be followed in order to improve the trees are: (1) breeding, (2) seedling selection, (3) artificial propagation. Of these methods the first is too tedious and costly for privately owned plantations, but it is desirable that work on this problem should be carried out by government agricultural departments. The selection of vigorous seedlings is desirable, but no means are yet available which will enable planters to select seedlings likely to produce trees giving high yields or prove resistant to diseases. Artificial propagation, by budding, grafting, cuttings or by "marcotting"—methods successfully employed by fruit growers for the propagation of desirable strains—are most likely to prove of practical value. The author suggests that old trees growing in a locality where the soil and climatic conditions resemble those under which cultivation is to be carried out should be carefully selected for propagating, and only those trees which give high yields of rubber and are free from disease should be chosen.

It is pointed out that the method of "marcotting" or ringing is laborious, and, although it has been carried out successfully on an experimental scale in Java (see p. 603), it should only be used if other methods are not satisfactory. Cuttings were made from early consignments of seedlings sent to Ceylon from Kew, and it should therefore be possible to propagate by this means. Budding is simple, and is stated to have been carried out on a plantation in Sumatra recently, but the author calls attention to the need of care in selection of the stock used both for budding and grafting, attention being paid to freedom from root disease and the possession of a well-developed root system; the stock could be grown from seed. The plants from which the buds or scions are taken should also be carefully selected.

The different methods of vegetative reproduction of Hevea have been described by Maas (*Mededeelingen Proefstation, A.V.R.O.S., Rubber Serie, No.* 21), and the results of a number of interesting experiments are recorded. The methods tried included the following: Forkert method of budding, patch-budding, and reversed T cuts; cleft-, paring- and crown-grafting; and marcotting or ringing.

Budding can be done on young branches of old stumps or even on seven-year-old stocks. With experience comparatively few failures result, and even after a week's practice 50–60 per cent. of the "buds" are successful. Of the grafting methods, cleft-grafting was the least successful, only about 40 per cent. of the grafts growing; side-grafting was easier to carry out, and about 55 per cent.

of the grafts were successful; crown-grafting gave the best results, 75 per cent. of the grafts being satisfactory.

In the process of marcotting, the stock, branch, or shoot formed after budding is ringed (*i.e.* a ring of bark and cambium is removed) or is cut into, and the ring or cut is wrapped up in a moist mixture of cow-dung, clay and coir-dust, the whole being prevented from drying by binding with waxed tape or encasing in a sheet of tin. Roots are eventually thrown out from the stem at the cut or top of the ring. This method is somewhat tedious, but may prove of great value. Marcotting of old branches even appears to be possible from experiments conducted by Keuchenius at Besoeki.

Cuttings were in some cases successful, but the results were not altogether satisfactory; cuttings from young plants ($\frac{1}{2}$ to $1\frac{1}{2}$ years) were better than those from older trees.

Diseases.—In India Hevea is chiefly grown in the south-western part of the peninsula, the area under rubber being about 60,000 acres, about half of which is fully tapped; most of the rubber was planted during two periods of activity, 1906–1908 and 1910–1912. The rainfall is high on most estates, viz. 120 to 140 in., rising to as much as 240 in. in some cases.

In 1909–1910 the demand for seed for planting, and later in 1913 efforts to utilise the seed, directed attention to the fact that the fruits were attacked by a disease which caused them to rot on the trees. It was also noticed on the oldest estates that leaves fell during the heavy weather of the monsoon, and that the yields of latex were not so great as were expected.

During 1915 a good deal of information was gained about the fruit rot, abnormal leaf fall and a rot of the tapped surface during the latter part of the monsoon, and it appeared that these were related. A species of *Phytophthora* has been discovered on the infected parts, and this has been shown to be the cause of the diseases.

This pest is now named *Phytophthora Meadii*, nov. spec., and its character, microscopic appearance, growth and effects on Hevea have been fully described by McRae (*Memoirs, Dept. Agric., India, Botanical Series*, 1918, **9**, *No.* 5). The fungus appears to become active after the dry season at a few points only, but spreads rapidly when the monsoon bursts, most likely owing to distribution of the spores in splashes from raindrops falling on infected fruits and by being carried by the wind to other trees.

The actual loss occasioned by the disease is difficult to

estimate owing to the fact that Hevea trees were infested with the fungus before planting was well established. The yields of rubber are, however, not up to expectations, and part of the shortage is due to *Phytophthora*, the average loss of rubber per acre per year being 30–40 lb., and as high as 70–80 lb. on areas which are badly attacked.

The fungus passes the dry weather in the mycelial stage, inside branches which have died back, while oospores are found in the fruits. These facts point to the cutting away of branches which have died back, and the removal of fruit or prevention of formation of flowers or fruit as possible remedial measures, and as a matter of fact the most promising remedial measures so far tried are the removal and destruction of dead branches and fruit. Where the bark is attacked it must be cut away, and the wound painted with tar and tallow. On estates where bark-rot is not usually severe, owing to comparatively low rainfall, tapping should be stopped on trees where bark-rot appears, while application of disinfectants to the tapping cut are also useful. The prevention of access of water to the tapped area by means of a strip of fabric tied round the tree above the tapped area seems likely to be advantageous.

Coagulation.—The use of sodium sulphite as an anti-coagulant is now very general. Results of analyses by van Hewm and Bertels of a number of samples of sulphite sold to rubber plantations in Sumatra show that the materials sold are sometimes quite devoid of sodium sulphite. Planters are advised therefore to guard against the sale of useless or inferior materials (*Mededeelingen Proefstation A.V.R.O.S. Rubber Serie, No.* 16).

Fibres

Alpinia nutans.—The extraction of fibre from the "wild ginger" (*Alpinia nutans*) is referred to in the *Colonial Reports Annual, No.* 1010, *St. Helena, Report for* 1918 (Cmd. 1–33). This plant grows rapidly in St. Helena, and is abundant and difficult to eradicate. During the early part of 1918 when phormium leaves were not available, the fibre-extracting machinery at the Government mill was modified and employed for the production of fibre from the "wild ginger" stalks. It was found that 255½ tons of stalks yielded only 3 tons 16 cwts. of fibre and 7 tons 14 cwts. of tow. The fibre was sold in London at £70 per ton, and the tow at £50 per ton. These prices, however, were exceptionally high, owing to the conditions created

by the war, and it was concluded that in normal times the extraction of fibre from *Alpinia nutans* could not possibly be remunerative.

Flax.—Some years ago attention was drawn to a method of retting flax in water inoculated with a pure bacterial culture. This method was described by Professor Giacomo Rossi, Director of the Institute of Agricultural Bacteriology in the Royal Higher School of Agriculture, Portici, Italy, in an article entitled "The Industrial Retting of Textile Plants by Microbiological Action," in the *International Review of the Science and Practice of Agriculture* (August 1916, 1067). The process depends on the action of a special aerobic bacillus, of which the prototype is *Bacillus Comesii*. In 1915 the Société Française de Rouissage Industriel was founded to work the Rossi patent, and a factory was erected at Bonnetable in the district of Mamers, Sarthe Department, France, where flax is now retted on a large scale.

At the request of Mr. Philippe Roy, Commissioner-General of Canada in France, a visit has been paid to the Bonnetable works by Mr. Alfred Renouard, a civil engineer, who has made careful observations of all the operations and the various stages of the process, and has prepared a report which has been published in the *Weekly Bulletin, Department of Trade and Commerce, Commercial Intelligence Branch, Canada* (1919, **20**, No. 803, p. 1185). The bacterial ferment employed in the Rossi method is an aerobic bacillus which is capable of consuming the pectinous matter in which the fibres are embedded, but does not attack the cellulose of which the fibres are composed. There is therefore no danger of the flax being injured if the normal time for the completion of the retting is exceeded.

The method consists essentially of three stages: (1) the immersion of the flax straw in water at 82–86° F. in suitable vats; (2) the addition of a certain quantity of a culture bouillon of the bacillus; and (3) the passage of a current of air through the water in the vats during the whole of the retting period.

The cultures are supplied from Prof. Rossi's laboratory in tubes ready for use in the preparation of the bouillon. The vats are constructed of reinforced concrete, and each has a capacity of 50 cubic metres (about 50 tons of water) and is capable of dealing with 5–5½ tons of flax straw. At the bottom of the vat and on each side is a branched pipe provided with holes, these pipes being used for the admission of air. Along the bottom and down the middle of the vat is a perforated tube of larger size for the introduction of steam to warm the water. The water enters

the vat through another pipe, each vat being thus supplied with three sets of pipes, each set being controlled by a separate valve, *i.e.* one for the air, a second for the steam, and a third for the water.

The bundles of flax straw are laid flat in the vat and placed side by side until the vat is filled. Water is then introduced, the flax being held down by wooden strips as it tends to rise above the surface. Steam is introduced to raise the temperature of the water to 82–86° F., and the culture bouillon is then added. Air is now passed into the vat from an air compressor which delivers 200 litres of air per minute to each vat. The operation is completed in 36–40 hours.

The bundles of retted flax straw are removed from the vats and conveyed to the drying ground, where they are spread out on the grass. After a few days on the grass the flax is dry and ready to be subjected to the breaking process, but in the winter or during bad weather artificial drying must be practised. At the Bonnetable works, the artificial drying is effected by spreading the damp flax straw on racks in a specially constructed drying room, and submitting it to a powerful blast of hot air.

It is stated that the cost of equipping such a retting factory is comparatively small and the method of operating is very simple. The process is more economical than the so-called hot-water retting methods, and has the further advantage that no change of water is required during the operation. After the required temperature has been reached by the admission of steam, no further heating is necessary, as the fermentation generates sufficient heat to maintain the temperature. The water which is run off from the vats after the retting is finished is of a pale yellowish colour, and is almost free from odour.

After examining the different grades of flax produced at Bonnetable, Mr. Renouard considers that the Rossi process can furnish the best possible results from flax straw of any kind which may be treated. Moreover, as the process can be checked at any moment, the action can be so controlled as to give products answering to all the requirements of flax spinners. The yield of fibre amounts to about 20 per cent. of the weight of the flax straw.

It is mentioned that the Rossi retting process can also be applied to hemp and ramie, and that, according to tests made by Prof. Rossi, it appears that Sisal leaves when crushed and retted by this method furnish a good, white fibre of better quality than that produced in the usual way.

In connection with this microbiological retting of

fibres, it may be mentioned that, according to the *International Review of the Science and Practice of Agriculture* (October 1917, 1417, and April 1919, 477), Carbone and Tombolato have isolated an anaerobic bacillus from the mud of some of the Bologna hemp retting pits, which has been termed *Bacillus felsineus* and is capable of retting hemp and other textile plants. This bacillus has been found not only in the mud of hemp pits in the Province of Bologna, but has also been isolated from the mud of two retting pits of Rovigò and from certain retting products of the Province of Naples, and it seems highly probable that it is the active agent in the retting of Italian hemp. In conjunction with Saccharomyces, the bacillus rets hemp stalks in less than 2½ days at a temperature of 98–99° F. and has been extensively tested in the Italian hemp districts. It has been shown by Carbone that *Bacillus felsineus* is capable not only of retting hemp, but also of retting flax, ramie, nettle, Furcræa, Sansevieria, Agave and many other plants. It always produces a very rapid retting and furnishes fine, white, well-separated fibres.

New Zealand Hemp.—An account of the progress of the New Zealand hemp industry in St. Helena is given in *Colonial Reports Annual, No.* 1010, *St. Helena, Report for* 1918 (Cmd. 1–33). The exports during that year amounted to 516 tons of fibre and 222 tons of tow, of total value £61,136, as compared with 528 tons of fibre and 214 tons of tow, of total value £53,113, in 1917. The Colony was in the fortunate position of having good facilities for shipping the fibre, and, in view of the high prices obtained, the island has rather benefited than otherwise from the war. Most of the fibre shipped to the United Kingdom realised the maximum controlled price of £97 per ton. As a result of these high prices, however, the growers harvested their leaves too abundantly, and in many cases much too young, and consequently a shortage of leaves has been produced. During 1918 a long spell of dry weather was experienced which retarded the growth of the Phormium plants, and the plants were attacked to some extent by white ants.

Cotton

West Indies.—In a previous number of this BULLETIN (1919, **17**, 441) reference was made to a paper by Mr. S. C. Harland, B.Sc., on "The Improvement of the Yield of Sea Island Cotton in the West Indies by the Isolation of Pure Strains." The second part of this paper has now been

published in the *West Indian Bulletin* (1919, **17**, 210) and contains a detailed discussion of a further series of results obtained in St. Vincent and the analysis of data accumulated by Mr. W. Robson in Montserrat during 1916–1918, in experiments in which only self-fertilised seed was used and an examination was made of certain characters of every individual in a progeny row.

The results of this work show that, both in St. Vincent and Montserrat, Sea Island cotton, as grown commercially, is composed of a mixture of distinct strains which can be separated by self-fertilisation and selection. These strains are of varying merit with regard both to the yield of cotton and its commercial value, and the isolation of strains of superior yielding capacity is therefore a matter of importance.

Special attention has been directed to the effect of selection on the length of Sea Island cotton, and in this connection emphasis is laid on the following points. Plants bearing short fibre can be easily and rapidly eliminated from the commercial crop by the adoption of the pedigree method of cultivation. Slight differences of length of fibre, weight of fibre per seed, seed weight and weight of fibre per boll are hereditary, and are maintained from season to season. The yield can be increased by selecting plants possessing certain combinations of morphological characters. Careful observation should be made of the weight of fibre per seed and the weight of the seed, the former being correlated with the weight of fibre per boll and the weight of fibre per acre. Types of high seed weight should be grown, as the maximum weight of fibre per seed can only occur if the seed weight is also at the maximum. There is a strong correlation between parent and mean of progeny in respect of length of fibre, weight of fibre per seed and weight of seed. The character of a plant thus affords some indication of the kind of progeny it will produce, but, in general, the inherent worth of a plant can only be judged in terms of the average behaviour of its progeny. It seems probable that the length of fibre and the weight of fibre per seed are negatively correlated. In Montserrat a type of cotton yielding 60 mg. of fibre per seed has been isolated, whilst in St. Vincent no plant has been observed with a fibre weight of over 55 mg., and it appears that the particular combination of Mendelian factors which give rise to this particular Montserrat type has been eliminated from the commercial cottons of St. Vincent and also from those of St. Kitts. The yield of the St. Vincent and St. Kitts cottons could doubtless be increased by crossing them with the heaviest-yielding Montserrat strain,

and the whole question of artificial hybridisation is fully discussed.

A detailed account is given of a practical method for the improvement of Sea Island cotton, which is capable of giving valuable results in a comparatively short time.

An account of the cotton industry of Antigua is given in the *Rep. Agric. Dept., Antigua*, 1917–18. The area planted in that year amounted to 510 acres as compared with 280 acres in 1916–17, and, in addition, there were 60 acres planted in the neighbouring island of Barbuda. The yield of cotton in Antigua amounted to 52,372 lb. or about 102 lb. per acre, and in Barbuda to 7,577 lb. or about 130 lb. per acre. This rather poor result was due to several causes, the chief of which were (1) indifferent cultivation on some estates owing to lack of labour, (2) absence of proper implements for cultivating, (3) bacterial boll disease and attack by insect pests, and (4) boll-shedding caused by heavy rains. A large part of the cotton is grown as a native industry which will probably continue and increase. Unfortunately, the methods of cultivation adopted by the peasants are often unsatisfactory; but in one district, in which agricultural instruction has been given, the crop receives more careful treatment.

During the year 1917–18 a consignment of the hybrid cotton, Sea Island × Eustatius, a variety which was produced some years ago by the Agricultural Department of Antigua, was sent to England for spinning trials. The results of the tests showed that the cotton was not of sufficiently good quality to justify further development, and its cultivation has therefore been abandoned.

NOTICES OF RECENT LITERATURE

Cotton in British West Africa. By N. M. Penzer, B.A., F.R.G.S., F.G.S. With an introduction by The Rt. Hon. The Viscount Milner, P.C., G.C.B., G.C.M.G., His Majesty's Secretary of State for the Colonies. Pp. 53, Roy. 8vo. (London: Federation of British Industries, 1920.) Price 2*s*. 6*d*. (in cloth, 5*s*.); post free, United Kingdom and abroad 2*s*. 10*d*.

In the introduction to this work, the importance of the development of the natural resources of the British Colonies is pointed out in relation both to the welfare of the Colonies themselves, and to the increased production of raw materials required for the industries of the United Kingdom. In view of the enormous potentialities of the

Colonies for the supply of economic products, it is regarded as a matter of great importance that information should be collected on the various raw materials of different parts of the British Empire and embodied in the form of memoranda, such as are now being prepared by the Intelligence Department of the Federation of British Industries.

The present volume first gives an outline of the history of cotton growing in West Africa, and then deals consecutively with the position and prospects of the industry in Nigeria, Gold Coast, Sierra Leone, Gambia, Togoland, Cameroons, and the Lake Chad District. Statistics are recorded of the exports of cotton from these various countries, sketch maps of Algeria and the Lake Chad region are provided, and a bibliography of cotton from 1881 to 1920 is appended.

In general the information has been carefully compiled, but it is rather sketchy in parts and is marred by a number of misprints. The bibliography is far from complete, and in the case of some publications the reference given is not sufficient to enable the publication to be identified. The book, however, supplies a useful summary of the possibilities of West Africa as a source of cotton.

FORESTS, WOODS AND TREES IN RELATION TO HYGIENE. By Augustine Henry, M.A., F.L.S., M.R.I.A., Professor of Forestry, Royal College of Science, Dublin. Pp. xii + 314, Med. 8vo. (London: Constable & Co., Ltd., 1919.) Price 18*s.* net; post free, United Kingdom 18*s.* 6*d.*, abroad 18*s.* 8*d.*

The drastic clearing of our coniferous woodlands necessitated by the war, and the greatly enhanced price of building timber have brought home to the general public the importance of afforestation more effectually than many years of expert insistence. The economic aspect of the question has, however, been dealt with by several previous authors, and Professor Henry, whose general knowledge of the conditions of British forestry is unrivalled, has an entirely distinct and more novel subject to discuss. The relations of woodland to public hygiene involve the discussion of the connection between trees and climate, and in the first of his twelve chapters the author gives us an admirable analytical account of this connection as affecting temperature, rainfall, the melting of snow, water supply, floods and soil erosion. We could have wished that the results of other workers had been summarised in greater detail instead of being merely cited, and that the author had seen his way to discuss the very

different conditions brought about by the heavy rainfall of equatorial latitudes. As it is, he deals mainly with the temperate regions of the northern hemisphere. The complete change of front on the part of the medical profession as to the desirability of trees in the neighbourhood of sanatoria will be news to many readers; but, on the other hand, the advocates of ornamental tree-planting will be glad to have the many practical suggestions as to the species best fitted for towns. The greater part of the volume is devoted to what has been, and what can be, done in the afforestation of pit-mounds and water-catchment areas in the United Kingdom, and this portion of the subject is fully illustrated with maps and photographs of plantations of recommended species. The Society of Arts, under whose auspices the Chadwick Lectures, upon which the book is based, were delivered, is to be congratulated on its choice both of subject and of author, and it is to be hoped, as the author says in his Preface, that it may "interest the statesman, the student of economics, the engineer, the physician, and the layman, as well as the forester" in the importance of tree-planting.

Commercial Oils, Vegetable and Animal: With special reference to oriental oils. By J. F. Laucks. Pp. viii + 138, Crown 8vo. (New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1919.) Price 6*s*. net; post free, United Kingdom and abroad 6*s*. 4*d*.

As mentioned by the author in the Preface, this little book is "intended primarily for the non-technical man in the oil trade." In Chapter I the author attempts to deal within the limits of twenty-nine pages with the nature, preparation and uses of oils in general, and to describe briefly the chemical and other tests commonly employed for ascertaining their quality and purity. The author has carried out this difficult task fairly satisfactorily, though the statement on p. 8 that "extraction processes cannot be used for obtaining oil for edible purposes" is erroneous, as extracted edible oils have been manufactured for a considerable time.

Chapter II comprises the greater part of the book, and gives brief descriptions of the origin, character and constants of commercial oils. In this section the details of results obtained in the author's investigations of consignments of oriental oils imported into the Pacific Ports of America and the regulations relating to the grading and sale of the more important oils in the United States are of special interest. Chapters III and IV deal respectively

with the uses of oils and the methods of sampling oils, oil seeds and cakes. A table giving the constants of a number of the less common oils, with the country of origin and uses in some cases, is added, and also a few useful data such as comparisons of thermometric scales.

Although this little book contains a great deal of useful information, one is forced to confess that it produces a general feeling of disappointment, and it might be greatly improved without alteration in size. Perhaps the weakest part of the book is the information regarding the sources of the various vegetable oils. Japanese wood oil is said to be derived "from fruits of a tree grown in Japan" (p. 39), poppy seed oil "from poppy plant" (p. 46), sesame oil "from seeds of sesame plant" (p. 74), and there are other similar statements which do not convey information of appreciable value. The most serious error in this respect is the statement that palm oil is derived "from outside fleshy part of the palm tree" (p. 86). Soya bean oil is said to be "obtained from several plants native in China (etc.)," but in this case perhaps Lewkowitsch is to blame, for in his *Oils, Fats and Waxes*, from which the author has derived many of his statements, a number of synonyms are given for *Glycine hispida* which the non-botanist might be pardoned for mistaking for the names of different plants.

If errors were eliminated and certain improvements made, this book should satisfy the demand which undoubtedly exists for a work dealing concisely with commercial oils.

Applied Economic Botany: Based upon Actual Agricultural and Gardening Projects. By Melville Thurston Cook, Ph.D. Pp. xviii + 261, Demy 8vo. (Philadelphia and London: J. B. Lippincott Company, 1919.) Price 7*s*. 6*d*. net; post free, United Kingdom 8*s*., abroad 8*s*. 3*d*.

According to the preface this textbook is designed for teachers in high schools as a guide to experimental work, and as preliminary to the study of agriculture. An attempt is made to cover a very wide field, chapters dealing not only with the main organs of seed-bearing plants, but also with their histology, chemical composition and ecological relations, as well as forestry, plant diseases and plant breeding, gymnosperms, pteridophytes, bryophytes, thallophytes and bacteria. The inclusion of some of these topics seems to be defended on somewhat narrowly commercial grounds, as when it is said that "the greatest

value of the ferns at the present time lies in their great beauty for decorations . . . and we must not forget that the growing of ferns is an industry representing many thousands of dollars" ; but the inevitable result is a very sketchy treatment of subjects upon which the teacher of agricultural students requires the fullest and most thorough knowledge. In the description of budding and grafting, for instance, there is no mention of the cambium layers or their necessary contact, whilst to say of the hop that "it is used in making yeast" is, at least, liable to misapprehension. The teaching is, however, mostly exemplified by cultivated plants, and the last third of the volume is devoted to brief notices of twenty-seven Families containing economic plants. These naturally refer mainly to the products of temperate latitudes, the family Rubiaceæ being, for instance, dismissed with a reference to an encyclopædia for an account of coffee and quinine. A useful glossary with stresses marked on the accented syllables and a list of more advanced botanical books are added, whilst throughout the book practical exercises on the subject of each chapter are suggested, and lists of questions, which we should have thought any teacher could readily have drawn up for himself, are also given. The book is fully illustrated with text-figures which have necessitated the employment of a heavily clayed paper. Many of the author's diagrams are excellent—none the less so from a primitive rudeness which would be easily reproduced on the blackboard ; but some of the photographs, such as those of devices for seed distribution, of apples attacked by bitter rot, or of the sunflower, which is in fruit, and not in flower as described, are mere useless smears.

The book is certainly not expensive, as prices rule at present, and will serve as an interesting and generally accurate *aperçu* for the general reader ; but elementary teaching requires, we think, a more thorough grounding than is here afforded.

Catalysis in Theory and Practice. By E. K. Rideal and H. S. Taylor. Pp. xv + 496, Demy 8vo. (London : Macmillan & Co. Ltd., 1919.) Price 17*s*. net ; post free, United Kingdom 17*s*. 6*d*., abroad 17*s*. 9*d*.

The authors are to be congratulated on the production of this comprehensive textbook on catalysis, which will serve to fill a gap in modern scientific literature.

The importance of catalytic actions from the purely scientific as well as from the technical point of view has long been known, but a comprehensive treatise such as

this was needed to enable one to realise fully the wide field of chemical reactions and technical processes dependent on catalytic action.

The opening chapters deal with the history, theory and measurement of the velocity of catalytic actions ; the remainder of the work being conveniently divided into chapters dealing with such subjects as oxidation, hydrogenation, nitrogen fixation, and hydrolysis by means of catalysts, the applications of catalytic reactions in organic chemistry, the rôle of catalysts in enzyme action, and concluding with a chapter on catalysts in analytical chemistry.

Among the more important commercial and technical applications mention might be made of the hydrogenation of oils in which hydrogen (frequently itself produced technically by catalytic action) combines in the presence of a catalyst with the unsaturated glycerides of liquid oils with formation of solid fats ; the production of sulphuric acid by the catalytic oxidation of sulphur dioxide ; and the splitting of fats with production of glycerol and fatty acids. It is naturally impossible to deal at very great length in such a volume as this with the details of technique of industrial processes, some of which have already more or less voluminous textbooks of their own, but the authors have summarised the information in a very satisfactory manner.

It is obvious that this book, dealing with a highly specialised, but widely applicable, branch of science such as catalysis, cannot appeal to the non-technical and non-scientific reader, but it is intended for, and will be of great value to, students of chemistry and physics and to technologists.

The writing is clear and concise, the matter has been fully indexed and numerous references to original papers and standard works are given. The book is well printed and arranged, and forms a valuable addition to the growing but none too large literature of the subject.

BOOKS RECEIVED

Profit and Sport in British East Africa. By Capt. The Lord Cranworth, M.C. Pp. xiv +503, Med. 8vo., with Maps and Illustrations. (London: Macmillan & Co., Ltd., 1919.) Price 21*s.* net; post free, United Kingdom 21*s.* 6*d.*, abroad 22*s.*

Australia in Palestine. Edited by H. S. Gullett, Chas. Barrett and David Barker. Pp. xiv +153, Demy 4to. (Sydney: Angus & Robertson, Ltd.; London: Oxford University Press, 1919.) Price 10*s.* 6*d.* net; post free, United Kingdom 11*s.*, abroad 11*s.* 3*d.*

The South and East African Year Book and Guide. Edited annually by A. Samler Brown and G. Gordon Brown, for the Union-Castle Mail Steamship Company, Ltd. 1920 edition. Pp. iv +771, Crown 8vo. (London: Sampson Low, Marston & Co., Ltd.) Price 2*s.* 6*d.*; post free, United Kingdom 3*s*, abroad 3*s.* 2*d.*

British South-West Africa. "South Africa" Handbooks No. 92. Pp. 28, Roy. 16mo. (London: "South Africa" Offices.) Price 6*d.*; post free, United Kingdom and abroad, 7*d.*

Flax Culture and Preparation. By Fred Bradbury. Pp. xii +154, Demy 8vo. (London: Sir Isaac Pitman & Sons, Ltd.) Price 9*s.* net; post free, United Kingdom and abroad 9*s.* 6*d.*

Forest Management. By A. B. Recknagel and John Bentley. Pp. xiii +269, Med. 8vo. (New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1919.) Price 12*s.* 6*d.* net; post free, United Kingdom 13*s.*, abroad 13*s.* 2*d.*

Forest Products: Their Manufacture and Use. By N. C. Brown. Pp. xiv + 471, Med. 8vo. (New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1919.) Price 21*s.* net; post free, United Kingdom 21*s.* 6*d.*, abroad 22*s.*

Cement. By Bertram Blount, F.I.C., assisted by W. H. Woodcock and H. J. Gillett. Pp. xii +284, Demy 8vo. *Monographs on Industrial Chemistry.* (London: Longmans, Green & Co., 1920.) Price 18*s.* net; post free, United Kingdom 18*s.* 6*d.*, abroad 18*s.* 8*d.*

MANUAL OF THE CHEMICAL ANALYSIS OF ROCKS. By H. S. Washington, Ph.D. 3rd ed. Pp. xii + 271, Med. 8vo. (New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1919.) Price 11*s.* 6*d.* net; post free, United Kingdom 12*s.*, abroad 12*s.* 2*d.*

THE MINERALOGY OF THE RARER ELEMENTS. By E. Cahen and W. O. Wootton. 2nd ed., revised by E. Cahen. Pp. xxxii + 246, Crown 8vo. (London: Chas. Griffin & Co., Ltd., 1920.) Price 10*s.* 6*d.* net; post free, United Kingdom and abroad 10*s.* 9*d.*

THE PEAT INDUSTRY REFERENCE BOOK. By F. T. Gissing. Pp. xxiv + 292. (London: Chas. Griffin & Co., Ltd., 1920.) Price 7*s.* 6*d.*; post free, United Kingdom and abroad 7*s.* 9*d.*

DIRECTORY OF PAPER MAKERS, 1920. Pp. 260, Imper. 8vo. (London: Marchant Singer & Co.) Price 2*s.*; post free, United Kingdom 2*s.* 6*d.*, abroad 2*s.* 9*d.*

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Botanical names and titles of books are printed in italics, and authors' names in capitals

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